THE EXPLOSIVES ENGINEER

FORE-RUNNER OF PROGRESS IN
MINING-QUARRYING & CONSTRUCTION

NOVEMBER-DECEMBER · 1961

VOLUME 39 · NUMBER 6

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THE EXPLOSIVES ENGINEER

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Forerunner of Progress in Mining, Quarrying, Construction

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Views and opinions expressed by the authors of articles in this publication are their own, and they do not necessarily represent those of the publisher.

The Grand Canyon National Park holds a double attraction for the tourist. Not only can the sightseer feast his eyes on the grandeur of Mother Nature's handiwork but can, if he is so inclined, visit a mine down the sheer wall of the south canyon that is actually producing uranium.

The Orphan Mine, owned and operated by Western Gold & Uranium, Inc., is not primarily a tourist attraction. It is a real mine that is worked every day and produces a very high grade uranium.

R. L. Marks writes an interesting article on the history of the mine and of the production procedures currently used. Please refer to page 165.

* * *

The work of completing the ring of Atlas missile bases located at various strategic points throughout the United States goes on day and night. These ICBM bases are vital links in the nation's chain of defense and rank high in the priority list of projects that must be rushed to completion.

In the vicinity of Dyess Air Force Base near Abilene, Texas, the construction of a complex of Atlas missile-launching facilities is rapidly nearing operational condition. Working on a nonstop 24-hour work schedule, the men of Zachry-Brown Company are keeping the job progressing in a satisfactory manner and soon another important defense weapon will be activated.

The story of the construction of the Abilene ICBM base will be found on page 171. It is written by L. H. Houck, a frequent contributor to our pages.

EDITORIAL STAFF: James J. O'Neill, *Editor*; Thomas E. Miller, *Associate Editor*; Gertrude A. Donnelly, *Associate Editor*; Edward L. Grant, *Art Editor*; Howard B. Dickson, *Production Manager*; A. J. Ackerman, *Advertising Manager*; Montgomery R. Budd, *Director*.

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Jefferson Island, one of the so-called "Five Islands of Louisiana," has long been thought the repository of the ill-gotten gains of Jean Lafitte's pirate activities in the Gulf area. Searches did not reveal any buried gold, but while drilling for water in 1898 signs of salt were found; however, no serious efforts were made to mine this material until 1920, when a large shaft was sunk and salt-mining operations were started. After a fire in 1940, which destroyed the entire facility, the operation was completely redesigned and reconstructed and, today, is one of the most modern mining operations in the industry.

An article by James H. Hughes, Jr., describing the area and operations starts on page 179.

* * *

The story of how progressive management, modern techniques, and carefully planned development keep the highly successful Idarado Mining Company a leader in its field is told in the article starting on page 183.

A. C. Hilander, general superintendent of this operation, writes an interesting and instructive treatise on the technique and procedures in use at Idarado. Details on the methods of slope preparation, drifting and raising in use at this property, and their conception of progressive expansion are explained. Such attention to all phases of the operation made this property the largest producer of silver, copper, and lead in Colorado for 1960.

* * *

If you wish an index to the articles appearing in Volume 39 (1961 issues) of The Explosives Engineer, just mail us your request. The index will be available within a few weeks and will be mailed only on request.

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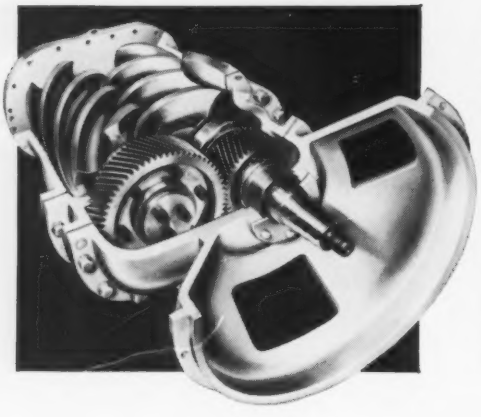

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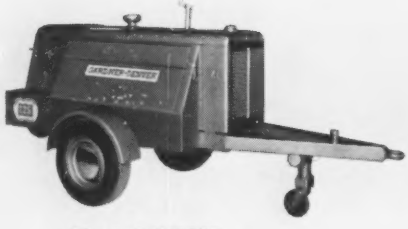

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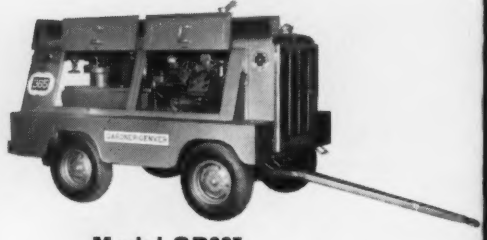

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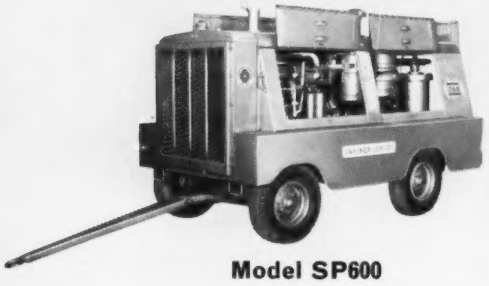

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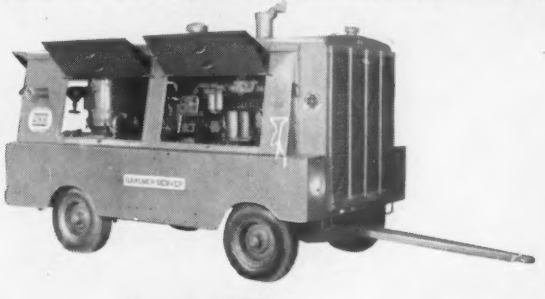

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THE EXPLOSIVES ENGINEER

1923-1961

With the November-December, 1961, issue, THE EXPLOSIVES ENGINEER completes its publishing career. For nearly 40 years, its unique approach to the reporting of events and ideas pertaining to the explosives-consuming industries filled a distinct need in its chosen field of technical journalism.

There was need for a magazine such as THE EXPLOSIVES ENGINEER in 1923. World War I had obscured the great civilizing force of commercial explosives. The inherent capabilities of explosives as a peacetime tool made possible great strides in mining, construction, road building, quarrying, seismic prospecting, navigation, land reclamation, and a host of other great manifestations of industrial growth. The scientific use of explosives was fostered by THE EXPLOSIVES ENGINEER; the present-day profession of explosives engineer is testimony to the recognition of explosives development and progress.

In cooperation with the U. S. Bureau of Mines, THE EXPLOSIVES ENGINEER sponsored a program of accident prevention, not only in the handling of explosives, but in other phases of safety in explosives-consuming industries. We are grateful and proud that the National Safety Competition will be continued under the aegis of the U. S. Bureau of Mines. The bronze Sentinels of Safety trophies, together with the name, have been turned over without reservation and at no cost to the Bureau.

Today, thanks to the maturity of the industrial press, there is competent and adequate, yes, even brilliant, coverage of those segments of industry previously considered the editorial sphere of THE EXPLOSIVES ENGINEER.

Accordingly, with reluctance, regret, and perhaps a tiny bit of personal anguish, we come full cycle in our publishing career. Looking back over the years, we are proud of the accomplishments of THE EXPLOSIVES ENGINEER. To our subscribers, authors, advertisers, and friends, thanks for allowing us to be with you.

M.R.B.

Mining Uranium on the Rim Of Grand Canyon

The Orphan Mine, in addition to being a rich uranium ore producer, is also an attraction to tourists visiting the Grand Canyon

R. L. MARKS*

ONE of the most colorful mining operations in the West is the Orphan Mine, a uranium producer of note, which has an adit far down the sheer wall of the south rim of the Grand Canyon in Arizona. It is said, in the West, that a good mine is usually at the end of an impossible road. For example, out in the red hills of the Big Indian country in Utah and elsewhere on the Four Corners Plateau, uranium was found in places so rugged that a seasoned burro had difficulties getting in and out of them. The Orphan, though a lonely thing, is in a better position roadwise; it has a winding pavement right up to the headframe and the Santa Fe Railroad hard by, but there things end abruptly, for only a few steps from the recently completed shaft is the rim of the yawning chasm of the Grand Canyon of the Colorado.

The Orphan, which is owned and operated by Western Gold & Uranium, Inc., is a real orphan: it is the only mine on the rim of the Grand Canyon. The claim covers 20 acres. On this ground near the mine is the Grand Canyon Inn, a totally owned subsidiary of Western Gold & Uranium. The National Park Service doesn't want the mine there; it particularly dislikes the surface installations, such as the inn. Recently, Congress has been working on a measure that would give the Park Service the authority to trade certain

AERIAL TRAMWAY: Although successful and spectacular, the aerial tramway didn't have the capacity for the most effective recovery of ore and has been replaced by a shaft. The tramway is still used for transport of men and equipment.

*Hercules Powder Company
San Francisco, California

mining concessions, for a fixed period of time, to Western Gold & Uranium for the company's surface installations other than those connected directly with the mine. This would give the Park Service the say-so about the surface and permit Western Gold & Uranium to work out its mine in the time designated.

Aside from being an orphan, the mine is unique in at least one other respect: it has had about the richest ore produced in North America. With selective mining from an aerial tramway, the mine maintained a grade of slightly over 1% uranium during the years 1957 and 1958. Such mining method, however, proved expensive, and the mine sank a 2½-compartment shaft, enabling the mining of lower grade ores in much greater tonnages.

DRILLING IN A STOPE: There is no fixed drilling pattern, as the mining follows the ore deposits. Air-operated Atlas Copco jacklegs and Ingersoll-Rand stopers are used in making the blast holes. The holes are drilled with 1⅞-in. detachable bits.

Historic Background

When one glimpses the lonely Orphan there on the red rim and hears of its unusual features, this thought pops into the mind: "My gosh! This thing must have an enticing history!" And it has.

Back in 1893, Daniel (Pop) Hogan, a seasoned prospector who knew well the taste of unseasoned beans and prunes, was clambering around the wall of the great canyon. Down the rim 1,100 ft. on a small tit of a shelf, he found what looked like a good show of copper. Hogan thought this was his rich strike and he started development; this was slow business because he had to climb down a combination of trail, ladders, and ropes to reach his diggings. When modern miners stand on the rim and look down the wall, they comment that Pop Hogan must have been part mountain goat or he never could have made it up and down the rim wall. With his facilities, it would have been most difficult to bring out a syrup bucket of ore. Remnants of Pop's trail and ladders can still be seen on the cliff near the Orphan tramway. But Pop managed to accomplish the required development work.

When the Spanish-American War broke out, Hogan quit his perilous mine and took up a somewhat less hazardous chore: he joined Theodore Roosevelt's Rough Riders and galloped off to war. When the war was over, Hogan hit the hills and the canyon walls again. In 1906, he filed for a patent on his claim on the canyon rim. His old commander in the Rough Riders, who had become President of the United States, was only too happy to sign the patent for Hogan.

Of course, this was a long time before Grand Canyon became a national park. When the park was established, the Park Service bumped into Pop's 20-acre claim in the big middle of things. It was private property granted by the United States. The Park Service couldn't boot out Pop unless he wished to sell, which he didn't. So there was the park and there was the claim.

Poor Pop Hogan! The claim did him little good. He came along about half a century too soon—nearly 50 years before the atomic age came mushrooming in and put an almost precious-jewel value on uranium. Hogan devoted a lot of sweat of the brow to climbing in and out of his mine and in digging in high-grade uranium ore, but in his time you couldn't swap the stuff for a drink of branch water.

When the uranium boom hit the West simultaneously with the explosion of the first atomic bombs, no stone remained unturned in a wild search for uranium. Of course, there was no point in any hungry prospector wasting time in a national park or monument, except on that tiny claim on the rim of the canyon. In 1953, Golden Crown Mining Company acquired mining rights to the claim after finding a promising uranium outcrop. Prospecting by airplane led to the find. The company began construction of its aerial tramway in 1955 and went into production in August of 1956.

Tourist Mecca

Many years after Hogan started the Orphan, Americans hit the road to see America first, and tourist travel became a flourishing business in the scenic West and particularly on the

south rim of Grand Canyon. The Grand Canyon Inn, the only private installation on the canyon's rim, was built on part of the 20 acres. In 1957 Golden Crown merged with its parent corporation, Western Gold & Uranium, Inc. However, the company's main enterprise is blasting out uranium ore down there in the innards of the canyon wall.

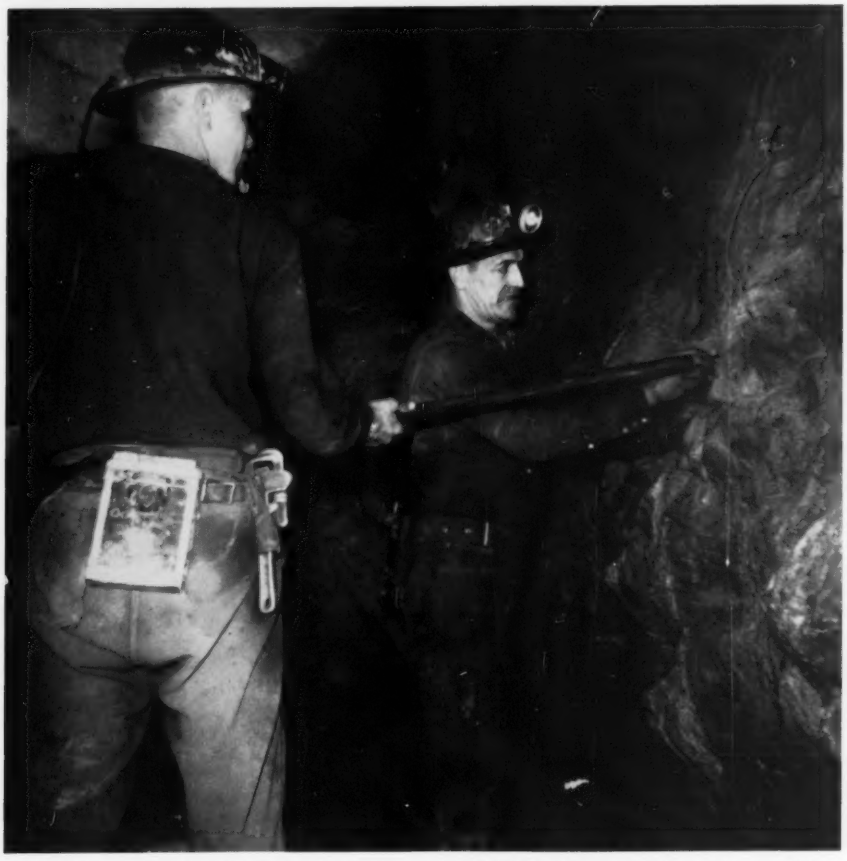
It is doubtful whether any other mine in the country has as many visitors as the Orphan, and to some extent this interferes with the work. The company has printed a small sheet of information about the mine for handing to enthusiastic tourists. It has also made available small chunks of ore, for souvenir-hunting tourists like to go home with pieces of real uranium—atomic bomb stuff—from the colorful Orphan.

The information sheet has a little map showing visitors how they can traverse a footpath one-third of a mile to Maricopa Point, where they can observe the mining operation. However, the information sheet begs the visitors to refrain from tossing rocks over the cliff because men are working down there.

The south rim of Grand Canyon is one of the more magnetic tourist attractions in the American West. It is open all year and it has large gatherings of tourists even in the winter. Here on the south rim, in full and majestic view, is one of the great wonders of the world, and it is no wonder the Government has protected it and equipped it so that people can see it and marvel at what nature and time have done there where the timeless Colorado River worms through the inaccessible ramparts of erosion down toward Lake Mead and Hoover Dam. The hilly park area is clad with pine, spruce, and other timber. The village of Grand Canyon is almost out of sight in the towering timber. Other installations include the appealing Bright Angel Lodge, which is operated by Fred Harvey; the El Tovar Inn; camp ground with cabins; and the park headquarters. The Bright Angel Trail, which is traversed by sure-footed mules, winds down from Bright Angel Lodge to the Colorado and a place called Phantom Ranch. Some tourists prefer the scenery from the Bright Angel bar rather than from the deck of a donkey on the trail. Near the lodge is the Shrine of the Ages.

The west rim drive winds along near the rim, and it has offshoot roads leading to the main scenic points, such as the Powell Memorial. Nearer the canyon is the rim walk, which twists and turns for miles only a few feet away from the very rim. Some tourists overestimate their vigor and walk so far on the rim that they wear themselves out and have to limp or crawl back or else send a more active person for a car. Snow on the highways leading from Williams and Cameron to the park doesn't stop the flow of tourists. The Santa Fe comes in there from Williams, and many visitors, especially in the winter, come in by rail.

The rim walk leads directly to the Orphan and humps around the 20-acre claim. Last year more than 1,000,000 carefree souls wandered wide-eyed through the Grand Canyon National Park, and something like half of them showed up at the Orphan Mine. They wanted to ride the aerial tram, and no one could blame them; probably the world's best view is from an ore bucket on the tram on its four-minute journey from the rim to the adit. Many tourists were insistent on riding the tram; some of them jerked out their billfolds and offered to pay the asking price for a ride. Others insisted on being taken into the mine. They wanted to see uranium in the raw, down in the earth; they wanted to see how it was mined.



PLACING THE CHARGES: The blast holes are loaded with Hercon in 1⅛ by 8-in. cartridges. Loading varies but will average one cartridge to the foot of hole.

Uranium Boom Over

The uranium boom is a thing of the past; its production has settled down to a routine industry. But millions of Americans have not yet seen uranium. To them it is magic stuff that might burn their hands. And to see uranium in a mine on the very rim of Grand Canyon would be something to brag about back home.

It may be that mine operators, busy

with their own work and puzzled to headache status by their own production, marketing, and labor problems, may be underestimating the public's interest in mining operations. As a general rule, tourists don't see mines. In some places in the West, there are observation spots at pit mines where the public can stop and enjoy an overall view. If it were possible for the public to see what goes into the mining of raw materials—the engineering, the equipment, the ingenuity, the drive it takes to run a mine profitably—the public might have a greater appreciation of the products made from the materials being mined. Quite a few mines in the West are actually more interesting and exciting than the natural scenery. And the Orphan is one of them.

However, there wouldn't be effective mining if an outfit were called on to show its operation to thousands of interested members of the public; moreover the matter of safety and liability is involved. Orphan has more of these problems than other operations, for it is doubtful whether there is another mine in the nation in the big middle of such a popular vacation spot. There seems a certain magic to a mine—and a uranium mine at that—on the rim of Grand Canyon.

Although the Orphan area often buzzes with humanity out to see what can be seen, the mine has a certain element of isolation. All the water used at the mine and in the company's other installations must be trucked 60 miles from Williams, Arizona. This runs up the cost of water to 1.1 cents per gallon. Consumption runs about 500,000 gallons a month in the summer and half that in the wintertime.

TYING IN A SLAB ROUND: A slab round usually consists of five or six holes which range from 20 to 40 ft. deep. Primacord is used in loading and hooking up the long-hole rounds.

Geology

Another factor that makes the mining operation a fascinating one is the geology. Of course, there is geology all over the place; as far as the eye can see in every direction there is a vast, fairyland world of geology that has been exposed by eons of erosion.

The Orphan pipe is 250 ft. in diameter at the adit level and 400 ft. in diameter on the 400-ft. level. The breccia material in the circular pipe has been altered. Of course, the Supai formation, the thin-bedded red sandstone, shale, and silt stone, is superbly exposed in the canyon walls, providing most of the coloring; it lies upon Redwall limestone and below the Hermit shale and is Upper Carboniferous or Permian in age. Coconino sandstone outcrops in the Hermit formation on the walls of the canyon near the mine. The Supai formation within the pipe has been altered. It is mainly grayish in color.

The rich uranium deposits are mainly in the periphery of the pipe, but large tonnages of lower content ore have been found in the center of the pipe. The highest grade ore body mined to date was within the pipe. Also found in small quantities in the strange formation are nickel, cobalt, lead, copper, gray copper, and traces of silver and many other minerals.

Apparently the forces—the deep-seated rock fusion and the pressure of hot gases or water—which formed the pipe also laid down the uranium deposits. There are both high lime and acid ore to be found in the deposits.

Mine Development

When the rich deposit was detected, the decision was to use the Pop Hogan adit 1,100 ft. down the wall. The electrically powered tramway was installed and equipped with ore buckets of 800-lb. capacity. Men and equipment entered the mine via the tramway, and the ore was hauled out on the tram. Although highly successful, the spectacular tramway just didn't have the capacity for the most effective recovery of ore, and a 2½-compartment shaft was sunk. It is 1,590 ft. deep. A station 120 ft. long, 25 ft. wide, and an average of 12 ft. high was cut on the 1,500-ft. level. A 900-ft. crosscut was driven from the station into the pipe and the mining area. The Centennial Development Company of Eureka, Utah, sank the shaft. It was put down with a cycle of drilling, shooting, mucking, and repeat. The job took a year. A 300-hp. electrically powered

Vulcan-Denver hoist was installed.

After the shaft was completed in 1958, production surged up to 200 tons of ore daily, about five times the capacity with the tramway. The shaft has a capacity of 400 tons a day. The tramway is still used, mainly to transport men and some pieces of equipment into the upper workings of the mine.

Ore is mined on several levels. Levels in the mine are designated with the tram adit as the top. Actually, the mine is 1,500 ft. from the top of the canyon rim. Reference to levels means at or below that of the tram adit. Ore is obtained at the adit level and at 100 ft., 175 ft., 245 ft., 310 ft., 320 ft., and 400 ft. The main rail haulage line is on the 400-ft. level, the same as the bottom of the station at the shaft.

Drilling and Blasting

Drilling and blasting in the Orphan follow no fixed pattern, since, in the main, the mining follows the ore deposits. Continuous radiometric assays are run in the mine to determine the content of the ore. The mining method consists of two types of stoping—open stoping and cut-and-fill stoping.

Air-operated Atlas Copco Swedish drilling machines, most of them jacklegs, are used in drilling the blast holes. Ingersoll-Rand J48 stopers are used mainly for drilling the up holes. Air is supplied by a Joy compressor of 1,800-c.f.m. capacity and by Atlas compressors of 600 c.f.m. Atlas Copco drill steel in 6-ft. lengths is used. As a rule, a hole is started and finished with the same steel. On long holes, which are started at 1⅞ in. and are finished at 1⅝ in., there are usually three changes of steel. The holes are drilled with 1⅞-in. detachable bits, with tungsten carbide inserts, made by Timken and Ingersoll-Rand.

Because of the varying material and faces, there is no fixed pattern for drilling blast holes. Each round is drilled and loaded to fit the peculiar condition in that spot. In drifting, the average round consists of 26 holes 6 ft. deep, with a burn cut made of four holes, 6 in. apart, only two of which are loaded. Some of the long holes are up to 20 and 40 ft. deep, usually five to six holes in a slab round.

The blast holes are loaded with Hercon® (E.P. 160 2x) in 1⅛ by 8-in. cartridges. Loading varies round by round, but it averages one cartridge of explosive to the foot of hole. The powder is tamped as the hole is loaded. The bottom cartridge in each hole is primed with a delay electric blasting cap. Delays from periods 1 to 10 are used. Leads are hooked up to a blasting wire which is plugged into a 220-volt circuit to fire the shot. Primacord* is used in loading and hooking up the long-hole rounds.

Satisfactory results are obtained. Occasionally, in some of the long-hole rounds, some secondary blasting—popping a few big ones—is necessary to bring all the material down to the size for efficient handling. Because of the differences in ground and the various faces for stoping, drifting, and exploratory work, no powder factor—that is, the tonnage of material in the solid broken to the pound of explosives—has been computed; but satisfactory results are obtained.

MUCKING: Mucking machines load the blasted material into man-operated cars that are unloaded into ore passes or raises. All material travels by gravity to the 400-ft. level.

Mucking and Hauling

All blasted material eventually travels by gravity down to the 400-ft. level and is moved over the main haulage line to the shaft.

Eimco 12B mucking machines load the blasted material into man-operated cars that are unloaded into ore passes or raises. In some sections of the mine, Eimco 21 muckers are used.

There is a slusher drift on the 265-ft. level. Blasted ore coming into it through the passes or raises is raked, or hoisted, to a pass where it goes on down. On the main haulage line, cars are loaded from ore chutes in the gravity system.

Cars are 2-ton rocker-dump type made by C. S. Card. They are pulled, usually in a train of ten, by 3-ton Mancha electric (battery) locomotives. The cars dump into a slusher trench at

*Reg. U. S. Pat Off. by The Ensign-Bickford Company

the station and from there the ore goes into two measuring pockets that empty into the skips. The material is hoisted to the surface in the skips, which unload into a 200-ton ore bin. The bin is equipped with chutes for loading into the trucks.

The G. L. Gibbons Truck Lines hauls the ore on contract to the Rare Metals Company mill at Tuba City, Arizona, 92 miles from the mine, where it is processed. The recovered uranium is sold to the U. S. Atomic Energy Commission. Gibbons uses belly-dump trucks which load from chutes at the rim ore bin. Acid ore goes to Tuba City. Prior to July, 1961, Western Gold & Uranium shipped by rail about 500 tons of high-lime ore per month to the Phillips plant at Grants, New Mexico. Phillips is equipped to handle the high-lime ore.

The mine operates the year round, and so do the ore trucks on the long haul to Tuba City. The weather, although it can get pretty wild in that wild land, hinders little. At times the temperature on the canyon rim drops to minus 22°F., and as much as 36 in. of snow accumulates. During extreme weather the ore trucks have some difficulty on the winding mountainous road from Grand Junction to Cameron in the Painted Desert.

The mine is clean and, except for a few places, is dry; there is very little water trouble, and almost no timbering or other support installations are necessary. Ventilation is exceptionally good; nature takes care of that in an unusual way: in the winter, fresh air pours into the mine at the tram portal, and doors are installed to cut down on the flow; in the summertime, the air enters the mine at the shaft. All working areas of the mine, the shaft, and the office are connected directly by telephone. Western Gold & Uranium observes accepted safety measures and the mine has maintained an excellent record.

Ore being mined is mainly in the periphery of the pipe. However, at times ore is hit in drifts through areas thought to be barren. The ore in the center of the pipe is of commercial grade and much of it may be recovered later on. Exploratory work, mainly core drilling, is in progress all the time, not only to test areas being mined, but also to seek additional deposits.

Mining and exploration are on two shifts—8 a.m. to 4 p.m. and 6 p.m. to 2 a.m. About 70 men work underground and seven on the surface, not counting the contract truckers.

Equipment is maintained underground and in a modern machine shop on the surface. Batteries on the locomotives are charged underground.

ORE SPECIMEN: A mine official examines a sample of ore taken from the Orphan Mine. Small chunks of ore are available for souvenir-hunting tourists who visit the property. A printed sheet giving information about the mine is also distributed to visitors.

Recent Acquisition

As recently as last September, Western Gold & Uranium, Inc., acquired the Lee Ackerman Investment Co., Inc., of Scottsdale, Arizona.

In addition to the Orphan Mine, the Grand Canyon Inn, and the Lee Ackerman Investment Co., the company operates Western Village Trailer Camp, which is just outside the national park. The camp has 28 bunkhouses and 48 house trailers. The company owns other mining properties in Arizona, Utah, and Colorado.

The company's home office has recently been moved from New York City to Phoenix, Arizona.

Company officials include Richard W. Ince, chairman of the board; Lee Ackerman, president; David P. Shirra, executive vice president in charge of operations; Charles E. Prior, mining director. Other officers are Robert W. Bull, Jr., Edward Bierma, and Melvin Conant. Maurice Castagne is superintendent of the Orphan Mine; Max E. Kofford, chief geologist; and Henry H. Leigh, controller.

TEXAS BASES
For the Atlas ICBM

Skill and speed are the key words as Zachry-Brown crews rush to complete vitally needed ICBM underground bases

L. H. HOUCK*

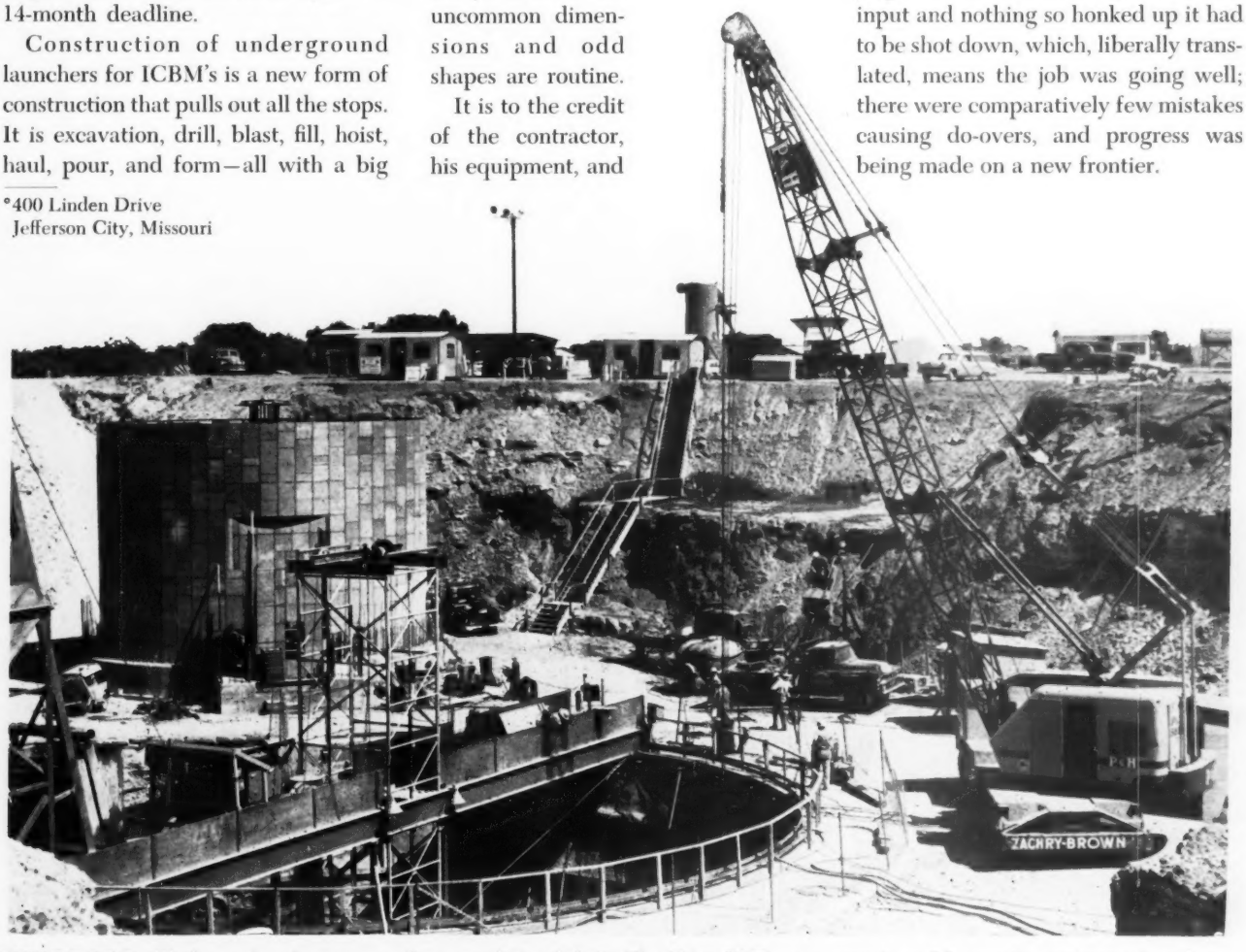
SKILLED construction men are pulling production rabbits out of hard hats at Abilene, Texas, where several Atlas missile launch complexes are being rushed to completion on a non-stop 24-hour work schedule against a 14-month deadline.

Construction of underground launchers for ICBM's is a new form of construction that pulls out all the stops. It is excavation, drill, blast, fill, hoist, haul, pour, and form—all with a big difference. Dimensions are often fantastic. When plans call for concrete 7 ft. thick or more, it's not an error in the plans. It still means feet and not inches. It's strictly a blueprint job in every detail where uncommon dimensions and odd shapes are routine.

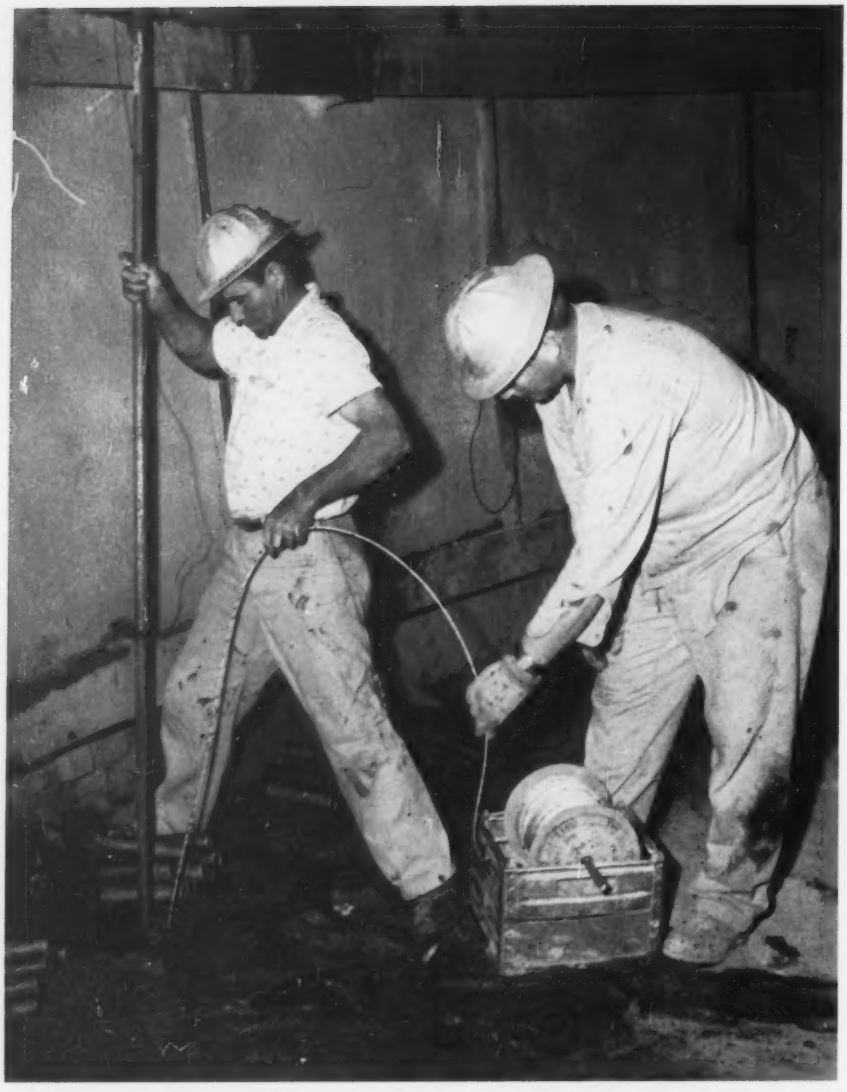
It is to the credit of the contractor, his equipment, and his experienced crews that this space-age project was essentially on schedule; however, a lot of construction men were behind in their sleep.

In missile-eze, the new space-age jargon, there were no rinkydinks in the input and nothing so honked up it had to be shot down, which, liberally translated, means the job was going well; there were comparatively few mistakes causing do-overs, and progress was being made on a new frontier.

*400 Linden Drive
Jefferson City, Missouri



MISSILE SILO: Work area in primary excavation around top of shaft. The 45-ton P&H motor crane is used for moving equipment in and out of the silo. It also swings a man cage for working on the steel rings in the circumference of the shaft.



LOADING: Holes for a typical shooting pattern were drilled on a 4 by 4-ft. spacing in the center area, while the perimeter holes were drilled 2 ft. apart and 4 ft. from the nearest center hole area. Of the 199 holes, 83 were perimeter holes and 116 were center area holes.

Missiles Are Bullets

The Defense Department defines missiles as bullets and the missile bases and launching sites as guns. Atlas missiles are in full production at Convair's San Diego plant.

Construction of the complex of Atlas missile-launching facilities in the vicinity of Dyess Air Force Base, Abilene, Texas, is the responsibility of the Corps of Engineers Ballistic Missile Construction Office, and a construction contract was awarded to Zachry-Brown Co., Abilene.

Zachry-Brown is a joint-venture company, composed of two large and well-known Texas construction firms of wide experience: Brown & Root of Houston and H. B. Zachry Co. of San Antonio. Bids were opened in Abilene on May 26, 1960, and construction started a few days later—on June 1.

The Atlas ICBM

The Atlas (SM-65), America's first intercontinental ballistic missile, was developed in a flight-test program begun in 1957. With associated ground equipment, it comprises the Air Force weapon system WS-107-A-1. The Atlas is produced for the Air Force at San Diego by Convair (Astronautics) Division, General Dynamics Corporation.

Atlas was the first missile to lift itself into orbit without extra rocket stages and is now being used in a number of pioneer space projects. Almost daily it establishes new records of reliability and distance.

While the Atlas is designed to deliver a thermonuclear warhead more than 6,000 miles, it has gone beyond 9,000 miles with uncanny accuracy and has traversed a 7,000-mile course to target. It is powered by liquid-propellant rockets—two large boosters, one large sustainer, and a pair of small vernier rockets, all burning liquid oxygen and a kerosene hydrocarbon RP-1.

Takeoff thrust is approximately 360,000 lb., and takeoff weight about 260,000 lb. The missile is 75 ft. long, 10 ft. in diameter; some models have long pointed noses, making them some 82 ft. long.

The Atlas Silo

There are two underground components at each Atlas missile launching site—the missile silo and the launch control center. The silo, approximately the height of a 17-story building (174 ft.), is built entirely below the ground surface. It serves as garage and filling station for the missile. The inside diameter of the finished silo is about 52 ft. The walls in the upper 29 ft. of the silo are at least 9 ft. thick, and from that point the walls taper to a thickness of some 2 ft. 6 in. in the next 26 ft. A 30-in.-plus wall thickness prevails for the remainder of the silo.

The top of the silo is flush with the natural ground surface. Approximately 17,500 cu. yd. of material is excavated for each silo. Open-cut excavation to the bottom of the launch control center amounts to approximately 60,000 cu. yd. Foundation excavation below the floor varies from 8 to 16 ft., depending on the type of soil encountered.

The silo and launch control center contain approximately 5,500 cu. yd. of concrete and 1,600 tons of reinforcing steel. Overhead doors for the silo are of reinforced concrete 2½ ft. thick and

weigh approximately 70 tons each; they are to be operated hydraulically.

The missile crib is a large steel structure extending the entire depth of the silo and is suspended in the silo by spring supports. The crib serves as the launching platform and maintenance shop for the missile, and also contains the fuel-loading system. There are eight floor levels in the crib, with one level being divided into additional sublevels. The first-floor level is at the top of the crib and the eighth-floor level is at the bottom. The base of the missile will rest on the sixth-floor level. Levels below the sixth are filled with pumps, tanks, piping, valves, and controls, which are integral units of the propellant-loading system for the missile.

Access to the various floor levels is provided by a personnel elevator and by a spiral stairway.

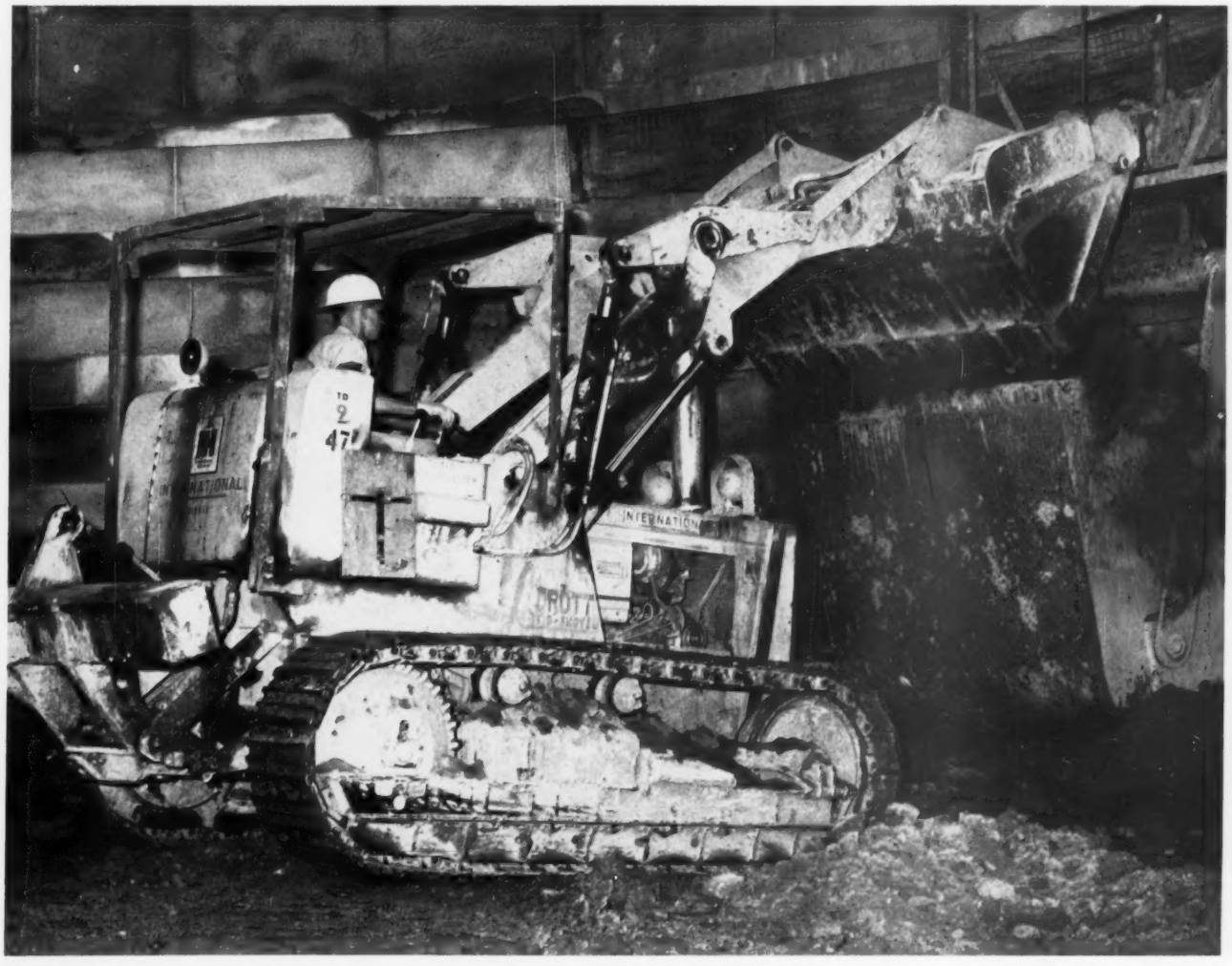
The entire unit is designed with a heating, air-conditioning, and ventilating system, which controls temperature and humidity.

The Launch Control Center

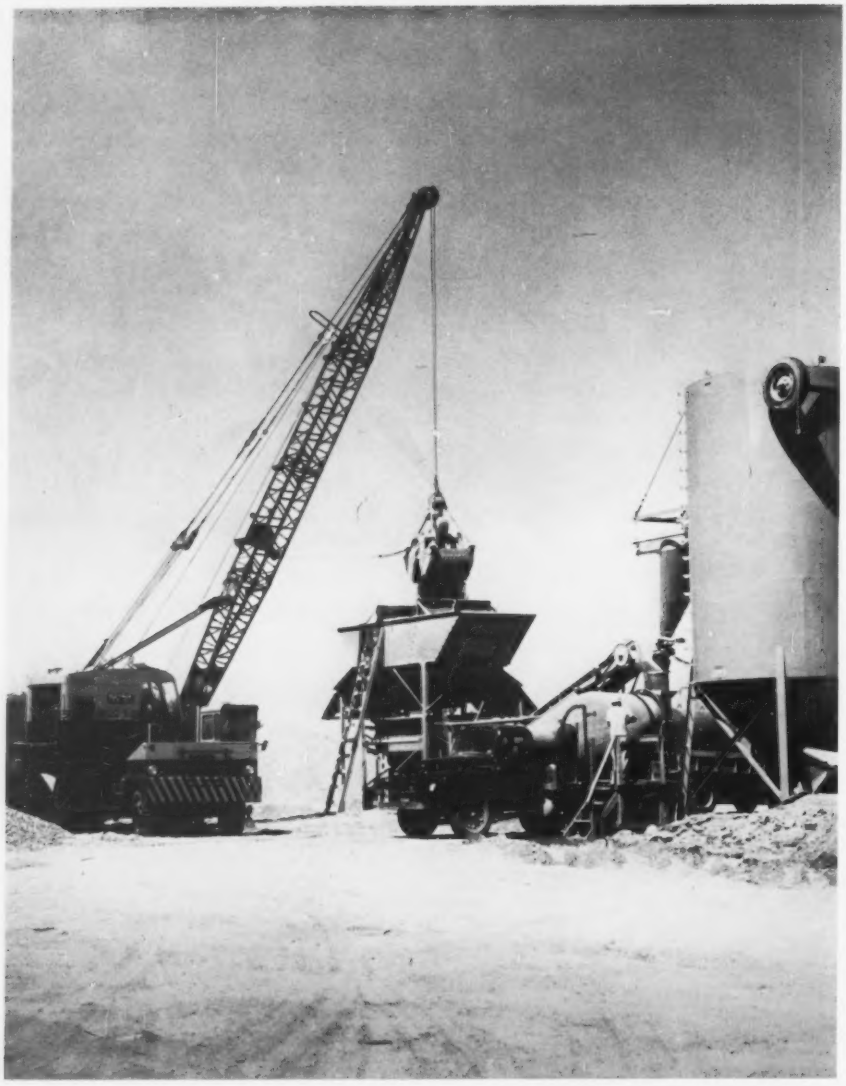
The launch control center houses the missile crew and the launching controls. The control center is 40 ft. in diameter and has a height of 30 ft. from the top center to the finished floor slab. The walls of the center are 2 ft. 3 in. thick. The top of the control center is 8 ft. below the surface.

The distance from the center of the control center to the center of the missile silo is about 100 ft. The unit is the equivalent of a two-story building, with the first floor being used for personnel quarters and the second floor for communication and launch control equipment. Excavation for the control center requires removal of about 2,000 cu. yd. of material.

The two underground units will be connected by a tunnel having an 8-ft. inside diameter—the passageway between the control center and the silo beneath the surface of the ground. This tunnel will have two sets of doors to protect the crew during firing operations. The launch center, like the silo, is equipped with a heating, air-conditioning, and ventilating system.



MUCKING: A 2-cu. yd. skip bucket is loaded by an International TD-9 equipped with a Drott high-lift bucket of 1½-cu. yd. capacity. Equipment is lifted out of the silo by a 45-ton crane prior to blasting.



CONCRETE PLANT: Portable plants similar to this were set up at all missile sites. These units consist of a 22-B Bucyrus-Erie crane with clamshell and portable cement bin. Transit-mix trucks transported the concrete to the job site.

This is a description of one unit, of which there are several under rush construction at Abilene.

If a nest of missiles is called a complex, no less aptly named are the various divisions of control over launching base operations, construction, and final operational control.

The Atlas achieved operational stability in 1959 and the operational force is a part of the Strategic Air Command. SAC's 1st Missile Division is located at Vandenberg Air Force Base, Lompac, California, and is a combined operational and training base. The first SAC-launched Atlas was fired from Vandenberg by the 576th Strategic Missile Squadron on September 9, 1959.

Work has been completed on the following bases: Francis E. Warren Air Force Base, Cheyenne, Wyoming; Offutt AFB, Omaha, Nebraska; Fairchild AFB, Spokane, Washington; Forbes AFB, Topeka, Kansas; Schilling AFB, Salina, Kansas; Lincoln AFB, Lincoln, Nebraska; Altus AFB, Altus, Oklahoma; and Dyess AFB, Abilene, Texas. Facilities constructed at Walker AFB, Roswell, New Mexico, and Plattsburgh AFB, Plattsburgh, New York, are scheduled for completion in 1962.

The Corps of Engineers, U. S. Army, is responsible for acquisition of real estate for Atlas missile sites as determined by the Air Force, and for construction of silos and launching facilities as designed by the Air Force.

The Dyess AFB Complex

Each of the several launching sites at Dyess AFB, Abilene, Texas, required 8.31 acres of land for the location of the silo, which was purchased in fee title. Additional requirements were approximately 3.18 acres of land in fee title for right-of-way for an access road to the nearest highway, and 8.03 acres of land for construction easement area.

Location of military defense facilities in this area is not new to Abilene, Texas, named for the famous cowtown of Abilene, Kansas. Some of the most famous frontier forts were once located in the area. The historic remains of Old Fort Griffin are at Albany, only a few miles away. Fort Phantom Hill ruins are near the Anson missile site. A U. S. Army post was established at Phantom Hill in 1851 on the then-extreme western border and it served as an important link in a chain of protective forts across Texas. Abandoned by the Government in 1854, it was taken over by the famous Butterfield Stage Line as a rest and relay station, which was finally abandoned in 1880. Only the stone chimneys and some of the more stoutly built walls of the former post arsenal now stand.

Buffalo Gap, an early gateway for immigrants, trail drivers, buffalo herds, and roaming Indians, is a pass in a low line of hills of the Callahan Divide that traverses the area from west to east.

Two Excavation Methods

Zachry-Brown, contractor on the Dyess Atlas complex, divided the excavation into two phases to take advantage of two different methods. Primary excavation, totaling about 60,000 cu. yd., was done by the open-cut method and consisted of a circular excavation some 200 to 300 ft. in diameter, on a 4-to-1 slope of 15 ft. to a 5-ft. bench, and then to a depth of 35 ft. from the ground surface.

The bottom of the open cut is the top

elevation for using the other method of excavation, the sinking of a vertical shaft approximately 60 ft. in diameter to a depth of 140 ft. or 180 ft. from the surface of the ground.

The launch control center, which is 100 ft. from the center of the missile silo, is located in the primary excavation.

At most of the missile sites, the primary excavation was made in sandy soil and caliche but at some sites rock was just below the surface; at the Shep site, rock was at the top of the ground. The rock in the primary sites was drilled and blasted in the conventional way. Dirt was excavated with Caterpillar DW-21 scrapers, push-loaded with D8's, assisted by a Michigan 125A utility machine which was used in the general cleanup operation. Rock was loaded into a fleet of three 22-ton Euclid trucks with an 80-D Northwest 2½-yd. shovel.

From this point on, the job left the conventional and headed out in space for the unknown.

In the first place, the 180-ft.-deep underground silo nest for the Atlas presented the problem of sinking a circular shaft in rock to a depth of 140 ft.—a shaft which had a rough diameter of 60 ft. These problems of large and unusual sizes entered into all phases of the construction.

Contrary Geology

The geologic history of this region of Texas, described by an early geologist as the "most agonizing state geologically," has been largely a prehistoric process of reversing physiographic features. The plains that now spread over the state stand where two towering mountains once reared their summits, and mountains and high plateaus are now found where once were marshy plains and watery surface of great seas.

The missile bases that surround Abilene are located in a rolling plain and mesquite-dotted prairie, officially known as the "Rolling Prairies" of the North Central Plain. Distinguishing topographic feature is the Callahan Divide, the ridgecomb between the Brazos and Colorado Basins.

This is oil country, with commercial clay, sand, and limestone deposits, plus

TOP-SIDE ACTIVITY: This view of some top-side activity and equipment shows the shaft bridge of heavy steel girders and a hoist. In the left foreground, an Ingersoll-Rand air compressor is being serviced.

natural gas. The geology of the lower depths has been charted in thousands of volumes of oil history, which record for industry the various sands and the great limestone reefs in the lower depths. Lesser known and seldom used is information on the first 200 ft. down.

The rock encountered in excavating for the missile bases consisted of limestone, compact and hard, and a hard and brittle blue shale. Geologists have described some of the surface rock in the area as Blaine dolomite and anhydrites of the Double Mountain group of the Permian Age. But for sake of variety, not far below the surface are some 2,350 ft. of Pennsylvania limestone, plus layers of dark gray shales and sandstones.

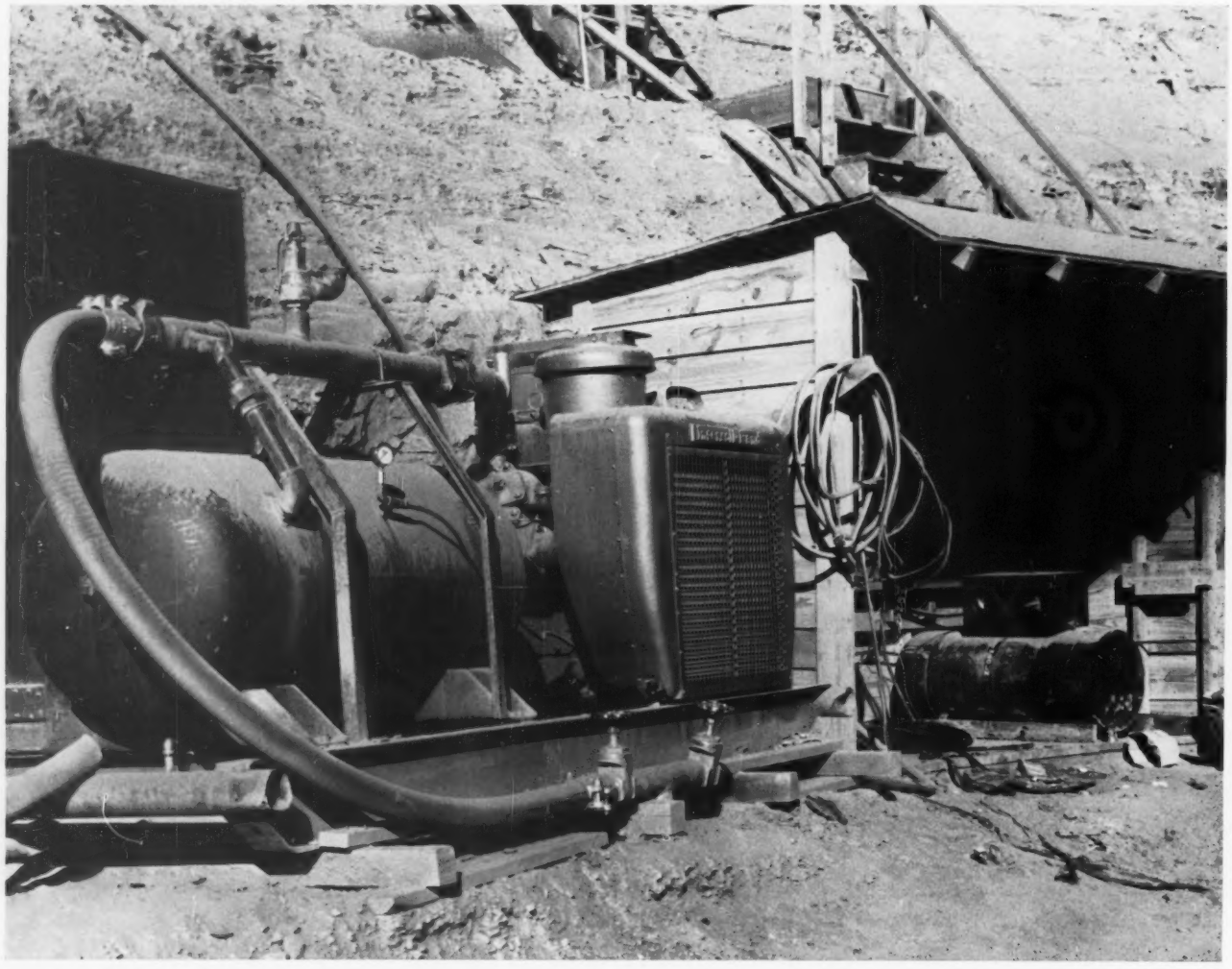
The presence of sandstone strata does little but lull the unsuspecting excavator into a sense of security. The sandstone is meager; the predominating blue shales are tough; and the limestones are hard and dense.

Ordinary drilling and blasting would have been no problem with this variegated rock structure but the required controlled blasting was a delicately balanced operation calling for shatter and good fragmentation without throw. The objective, which was reached, was to have a 20-ft.-deep section properly broken so that all mucking could be done with an International TD-9 with a 4-in-1 Drott bucket and front-end loader. Full protection had to be provided for the shaft wall lined with pneumatically placed concrete and ringed with giant steel rings, made with arched pieces of 8 by 8-in.-wide flanged I-beam, with the lowest ring always within a few inches of the top of the blast holes. There was protection to be provided for the steel framework of the personnel elevator which always extended from the top down to within 16 ft. of the bottom.

These problems, although neatly solved, took the sinking project out of the range of the ordinary.

Oversize Shaft

While oversize equipment may be much desired on construction jobs, such oversizes must be coordinated with all other equipment; otherwise, the too-big unit introduces problems all along the line.



COMPRESSED AIR: The air requirements at each site were supplied by electrically operated 900-c.f.m. Ingersoll-Rand compressors. Smaller air compressors, engine driven, were available at each site when additional air was required.

While that was not quite the case with the oversize shaft, there were many problems introduced by reason of the large diameter. These included problems of locations for hoist, how to hoist, location of personnel elevators, and other problems. A hatful of these problems was solved in a unique and original way by locating hoist, personnel elevator, and headframe and dump mechanism for skip bucket, along with truck chute, all on two large I-beams which spanned the top of the shaft through the middle.

This firm foundation consisted of two 36-in. I-beam steel girders, 65 ft. long, spaced 5 ft. apart, with suitable welded and bolted steel cross members of structural steel. Placed on one half was the dirt hoist, a conventional two-drum American general-purpose unit powered with an electric motor and operated by a hoisting engineer whose operating position permitted full view of the loading of his bucket in the bottom of the shaft. The headframe for the bucket, the self-dumping equipment, and the chute to parked trucks at the side of the shaft were included in the steel work.

The other half of the 5 by 65-ft. steel frame was floored and equipped with guard rails and steel netting, with a wooden floor providing entrance to the sliding door of the personnel elevator, or "man cage." This was an electrically operated elevator with "up" and "down" dead-man buttons for passenger operation, the cage stopping when hand was removed from the button. The frame and tracks for this cage extended downward as the sinking progressed, so that the bottom framework was never more than 16 ft. above the work at the bottom of the shaft. This distance was spanned by an aluminum ladder.

For handling the blasted rock that had been mucked and loaded by the TD-9, a 2-cu. yd. specially made steel skip bucket was used, which rode the side of the shaft in tracks of steel channel.

Some of the equipment had to be duplicated several times for the number of silos under construction, while other components were in duplicate only a sufficient number to keep the work moving. These steel outfits spanning the shafts were big and heavy, but readily portable. The work was spaced so that while some primary excavation was taking place, shaft sinking was going on in various stages at four of the sites.

Each shaft's top area was enclosed with a woven mesh wire fence and a walk around one half provided for workmen.

An International TD-9 with Drott front-end loading machine, previously mentioned, was used for all the mucking in each shaft. It could be lifted from the shaft with the 45-ton P & H transit crane assigned to each site. This crane also handled the traffic of all heavy tools in and out of the shaft, including the blast-hole drills. In its off minutes it handled a man cage for welding a heavy copper ground cable to all the steel rings, as well as the ring sections themselves. Steel rings were set as each 5 ft. was loaded out.

Blast-Hole Drilling

Blast-hole drilling was handled by eight Ingersoll-Rand Crawl-I-R drills, with compressed air supply from an Ingersoll-Rand 600-c.f.m., engine-driven Gyro-Flo compressor, assisted by a permanently located I-R electrically driven 900-c.f.m. compressor, which supplied air for all purposes at each site.

The usual method was to assign four of the eight drills to each shaft for the blast-hole drilling cycle, but sometimes five or more were used. Since drilling was a periodic chore, cycled with mucking, ring setting, concreting, and other jobs, eight drills proved a sufficient number when trucked to sites at the proper time.

Blast-hole bores were 2¾ in. in diameter, drilled to an average depth of 21 ft., using Timken detachable bits. During the drilling operation, drillers wore respirators, and a 24-in. fan helped pull out the dust-laden air.

A typical round shows the success of the drilling and blasting routine. Results were nearly ideal, with a minimum of overbreak and underbreak, and the break was mostly on the line around the almost 300 ft. of circumference.

This round was fired at the Oplin site, August 7, 1960, and consisted of 199 holes. Some of the rounds used as many as 221 holes. The round was drilled out by five drills running continuously for 24 hours. The somewhat complicated deck loading of the holes with dynamite was completed in 7½ hours.

The 199-hole round was loaded with 1,950 lb. of Gelamite® 2 in 2 by 8-in. cartridges. Deck loading consisted of 6 in. of dirt stemming between half cartridges in the upper 6 ft., and 12-in. dirt stemming alternated with single cartridges of Gelamite 2 in the remainder of the 21-ft. hole, except for two full cartridges in the bottoms of all center area holes and one cartridge in the bottom of all angled perimeter holes.

Spacing the loads for the deck-loading method was simplified by marking off the spaces on a tamping stick. In each alternate hole, stemming and dynamite were reversed so that a section of stemming would be opposite a section of dynamite.

The shooting pattern on this typical shot was one developed and used throughout the shaft sinking. Holes were drilled on a 4 by 4-ft. pattern in the center area, while the perimeter holes were drilled 2 ft. apart and 4 ft. from the nearest center area hole.

Of the 199 holes, 83 were perimeter holes, and 116 were center area holes.

The perimeter holes produced another problem. Since the steel rings encircling the shaft at 5-ft. intervals were set and grouted in as the shaft was mucked down each 5 ft., the last ring set before drilling a new round was always near the bottom. Because of its extension into the shaft area from the side, blast holes could not be drilled closer than 18 in. from the shaft wall.

Consequently, all perimeter holes were drilled at an angle that started

18 in. from the shaft wall and ended up on the break line 21 ft. below. This required different loading of explosives since there was 18 in. between the shaft wall and the hole at the top and none at the bottom. These holes were loaded by the deck-loading method similar to the center area holes, except they were loaded lighter at the bottom to prevent overbreak.

Holes were stemmed 30 and 36 in. from the top with heavy brown sand bought locally for that purpose.

No Vent® Short-Period Delay Electric Blasting Caps were used in delays 1 through 8 with 8-ft. leg wires. Each round was hooked up with plastic-reinforced Primacord,* this being used because of the wet conditions sometimes encountered. A Short-Period Delay Electric Blasting Cap was taped to the top of 20 ft. of Primacord which extended to the dynamite in the bottom of each hole.

A mat composed of large used airplane tires was lowered prior to detonation of the blasts to effectively smother the small throw.

The results of the typical blast described were nothing short of excellent. The rock was well fractured for high-lift loading, the break was neatly on the line. Detonation was with a Titan† blaster capable of firing 1,200 caps.

On this round, basing the yardage on the engineering formula of 96.3 cu. yd. per ft. in a 58-ft. 8-in. exact diameter, the explosive ratio was 0.96 lb. of dynamite to 1 cu. yd. of rock.

SUPERVISION: Fred Duke, general superintendent, discusses the progress of the work at the Oplin site with D. V. (Larry) Moore, project manager.

Key Personnel

Some of the best-known men in the construction industry were on this job. General construction manager for H. B. Zachry Co. was Cecil Morris. D. V. (Larry) Moore, project manager for Zachry-Brown, was in charge of all missile sites. John H. Strange was assistant project manager; Fred Duke, general superintendent; E. G. Stubing, assistant field superintendent; J. U. Biggers, office manager; Linn Maurer, project engineer; Eddie Kreusel, general superintendent for open-cut excavation; Bob White, equipment superintendent; Walter Wagner, dirt superintendent; and F. L. (Blackie) Glover, rigging superintendent.

Representing the Corps of Engineers, U. S. Army, is Lt. Col. A. M. Antonnelli, area engineer, with offices at Dyess AFB. The Corps of Engineers assigned an engineer to each site and a staff of inspectors for round-the-clock supervision.

Each site was operated as a separate construction job, with a separate site superintendent responsible only to general superintendent and project manager. This gave these executives authority and leeway to keep their individual jobs progressing as fast as possible.

Site superintendents were: Baird site, Don Smith; Denton site, Deb Phillips; Oplin site, Joe Edwards; Corinth West site, Jim Alexander; Lawn site, Buck Martin; Bradshaw site, Arthur Lentz; Winters site, Marvin Lentz; Anson site, C. B. Koonce.

*Reg. U. S. Pat. Off. by The Ensign-Bickford Company

†Hercules Trademark

Salt Mining On Historic Jefferson Island

An island in Louisiana's Creole country, supposedly the depository of Jean Lafitte's stolen gold, is now producing a different kind of mineral treasure

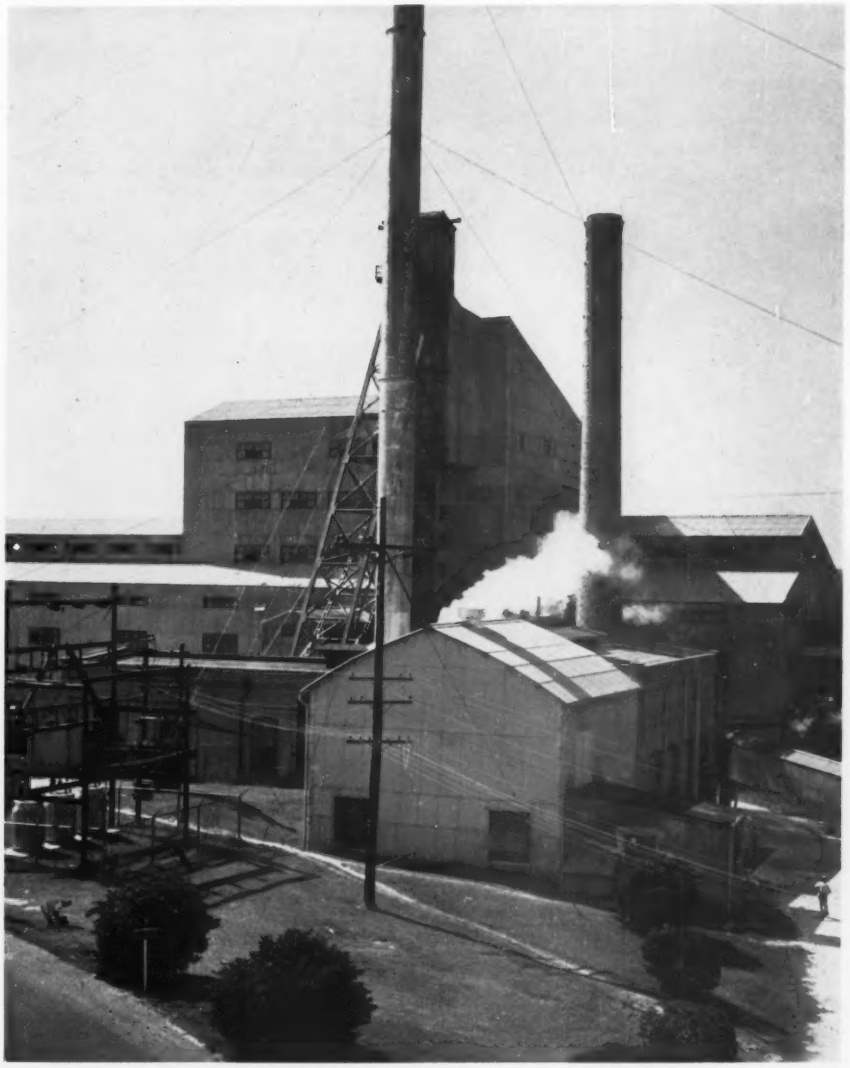
JAMES H. HUGHES, JR.*

FOLKLORE has it that the pirate Jean Lafitte buried his loot on Jefferson Island, deep in Louisiana's Creole country. Whether this is true or not matters little, for at a mine operated by Diamond Crystal Salt Company of St. Clair, Michigan, Jefferson Island yields treasure of another kind—4,700 tons of pure crystal salt in each 24-hour working day.

There are many versions as to how nature came to deposit this mineral wealth on Jefferson Island, one of the so-called "Five Islands of Louisiana," the inland islands stretching in a southeasterly line from a point near New Iberia to the Gulf of Mexico. The most widely accepted theory is that the weight of surrounding material, deposited in prehistoric times upon a bed of salt similar to that at the Great Salt Lake in Utah, caused the salt to flow upward through a fault in the earth's surface. This action resulted in a mushroom-shaped mass of rock salt with a stem extending 5 miles or more into the earth to the mother bed of salt. Regardless of how it came about, each of the five islands—Jefferson Island, Avery Island, Weeks Island, Cote Blanche, and Belle Isle—is a surface expression of a massive underlying mineral deposit.

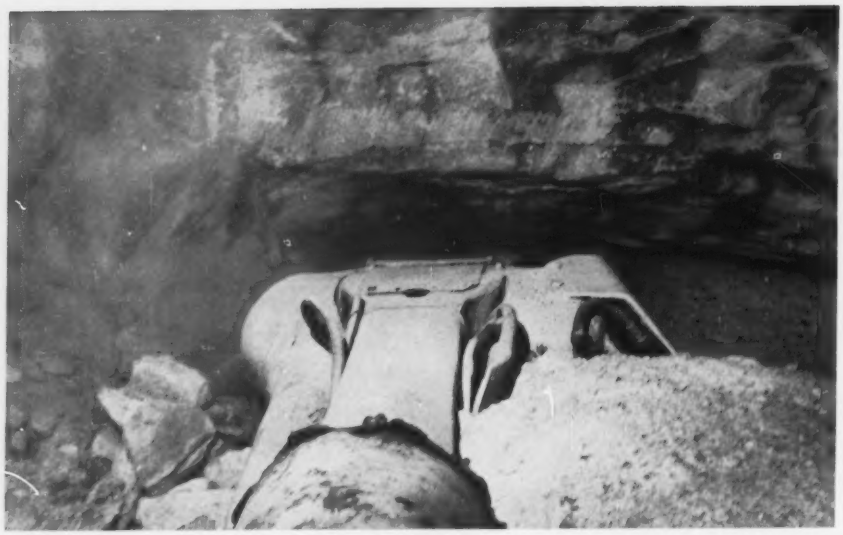
Colorful History

The colorful history of Jefferson Island dates back to 1784 when, acting under the Spanish Crown, Don Este-

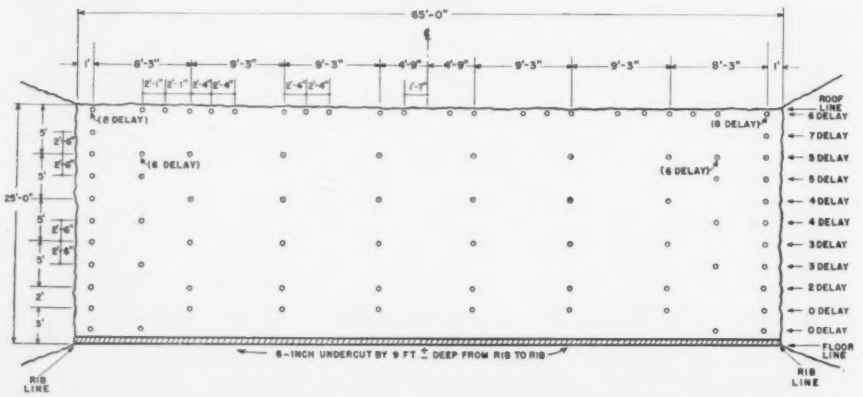


SURFACE FACILITIES: The Diamond Crystal Salt Company's plant at Jefferson Island is as high as a seven-story building. It houses screens for grading the salt, storage bins, and equipment for packaging and shipping the product.

*Denham Springs, Louisiana



UNDERCUTTING: The first step in making a face shot is to produce a 6-in. kerf. This Goodman electric undercutter cleans the kerf while cutting it.



DRILL PATTERN: This is the drill pattern used in making a typical face shot. The primary objective of the 6-in. undercut is to give relief for the initial fracture by the 0 period delay shots and also to make a uniform floor line.

DRILLING: Two hydraulically controlled drills, mounted on a jumbo, make the blast holes in the face. Eighty-two 1⅞-in.-diameter holes are drilled to a depth of 10 ft.

van Miro, governor of Louisiana, made a grant of land embraced by Jefferson Island to Messrs. Prevost and Carlin. Then known as Cote Carlin, the island was later sold to a brother-in-law of Lafitte, which gives rise to the story of buried treasure.

The first indication of mineral treasure on Jefferson Island came in 1898 when the island was owned by Joseph Jefferson, noted actor and artist who made the role of Rip van Winkle famous. Drilling for water, Capt. Anthony F. Lucas, mining engineer who attained lasting fame as the discoverer of the Spindletop Oil Field, found salt instead of water. No serious effort was made then to produce salt, and in 1917 a group of Kentucky businessmen bought the island as a game preserve. In addition to their game-conservation activities they also operated a rice mill and sugar plantation and raised Black Angus and Brahma cattle.

Beginning of Salt Mining

Still not satisfied, the group started drilling for salt and found one location where it was accessible. In 1920 they sank what was then the largest round shaft in the world—100 ft. in circumference. It was supported by iron railings, and more than 100 carloads of sand, gravel, and cement were used in lining the first 110 ft. of the shaft. The shaft was then continued to a depth of 800 ft., where salt-mining operations were started.

In 1940, while being operated by the Jefferson Island Salt Mining Co., the entire facility was destroyed by fire. It was redesigned by the firm of Allen and Garcia, consulting and construction engineers of Chicago. Operations of the completely redesigned and reconstructed facilities were resumed toward the end of 1941.

In 1957 the plant and mine were acquired by Diamond Crystal Salt Company, which also operates salt evaporation plants at St. Clair, Michigan, the home office, and at Akron, Ohio. Plants for the manufacture of individual service packets used generally on airlines, in hospitals, and drive-ins are located at Wilmington, Massachusetts, and Montreal, Canada.

Today, mining operations are carried out at the —1,000-ft. level, encompassing a rough rectangle 1,600 by

2,600 ft., and work has begun to drive a slope to a new level at –1,400 ft. below sea level.

Increased Production

Ten years ago the mine's capacity was 2,000 tons compared to the current production of 4,700 tons per 24-hour day. George S. Barber, plant manager, says experienced personnel, mechanization, and a change in the mining plan account for the increased production. Then and today, the operation is carried out by the room-and-pillar method, with rooms 65 ft. square and pillars 75 ft. square. Previously, the "low roof" was blasted in a face 25 ft. high from the original floor level, followed by blasting the "high roof" in the face an additional 60 ft. high. This was followed by a "floor shot" that added 25 ft. in depth from the original floor, giving a total of 110 ft. from subfloor to ceiling. Now one 25-ft. face is shot at the top level and the intermediate 60 ft. blasted down to the original floor level.

LOADING: The 10-ft. holes in the face are loaded with Hercomite 4 and detonated by delay electric blasting caps. Fragmentation is good and secondary blasting is seldom required.

Blasting

First step in the face shots is producing a 6-in. kerf with a Goodman electric undercutter. The company now uses a new mobile unit which eliminates the need for cleaning the kerf with shovels. An older model is retained as a spare.

Once the kerf is cut, two drills, which are controlled by hydraulic pressure and mounted on a jumbo, are moved into position. Eighty-two 1⅞-in.-diameter holes are drilled in the face to a depth of 10 ft. Horizontally the holes are 9¼ ft. apart all the way across the face. Beginning at the bottom, the lowest hole vertically is 3 ft. from the floor; the second 2 ft. above it; and the remaining holes 5 ft. apart.

The holes are charged with Hercomite® 4, tamped, and detonated with electric blasting caps. These blasts usually produce a depth of 9 ft. into the face. The present pattern provides good fragmentation, particularly in the face shots; in these shots, about 700 lb. of explosive yields 850 tons of salt. Secondary blasts are seldom needed in the face shots, according to V. L. Adams, mine superintendent.

Hercules® Electric Blasting Caps with aluminum shells and iron leg

SCALING: To prevent fall of rock and for tidy housekeeping, scaling operations take place after each blast. This hydraulically operated machine makes for efficient operation.

wires are used to detonate blasts in the mine. To maintain the purity of the product, electromagnets immediately in front of the secondary crusher remove the wire fragments from the salt, an accomplishment made possible by the iron leg wires.

Each blast is fired from the shaft at a prescribed time, generally at the end of each shift. A head count is made before each blast to make certain that the mine is clear.

The holes are loaded by mine personnel from a jumbo loading rig mounted on a Clark fork-lift truck.

For the floor shot, holes 2½ in. in diameter are drilled with a Gardner-Denver Air-Trac drill powered by a WDH 145-c.f.m. compressor. The holes are drilled 35 to 58 ft. deep, to within 2 ft. of the terminus of the salt block. The holes are charged with ammonium nitrate, which is primed with Hercomite 2. The primed holes are tamped with 2 ft. of salt. The floor shot produces about 1,800 tons of salt; in this case fragmentation is not as complete as in the face shot. Oversize chunks are broken up with half to a quarter of a cartridge of 1½ by 8-in. or 1¼ by 8-in. Hercomite detonated with safety fuse and blasting cap.

Loading Out the Salt

The salt produced by both types of blasting is picked up by either front-end loaders or a Bucyrus-Erie 38-B shovel. The front-end loaders now used are two Hough—one Model HO and one Model H90—and one Michigan 275A.

Three 17-ton Euclid dump trucks and a 27-ton Euclid dump take the salt from the blast site to the primary crusher, which can reduce a chunk of salt weighing upward of a ton to a maximum size of 8 in. in seconds.

Maintenance Problems

All of the heavy equipment must be disassembled and lowered piecemeal down the skip shaft. In the case of a dump truck, for example, this process takes about two weeks. When some items are worn out, they are driven into an abandoned section of the mine and left, because it would be too costly to dismantle them and remove them from the mine. Corrosion is a surprisingly mild problem in the mine, thanks to a lack of moisture; above the ground, however, corrosion is being fought constantly.

Processing

From the primary crusher, the salt is taken by conveyor belt to the secondary crusher, where mine fines are, for the most part, diverted into an abandoned section of the mine.

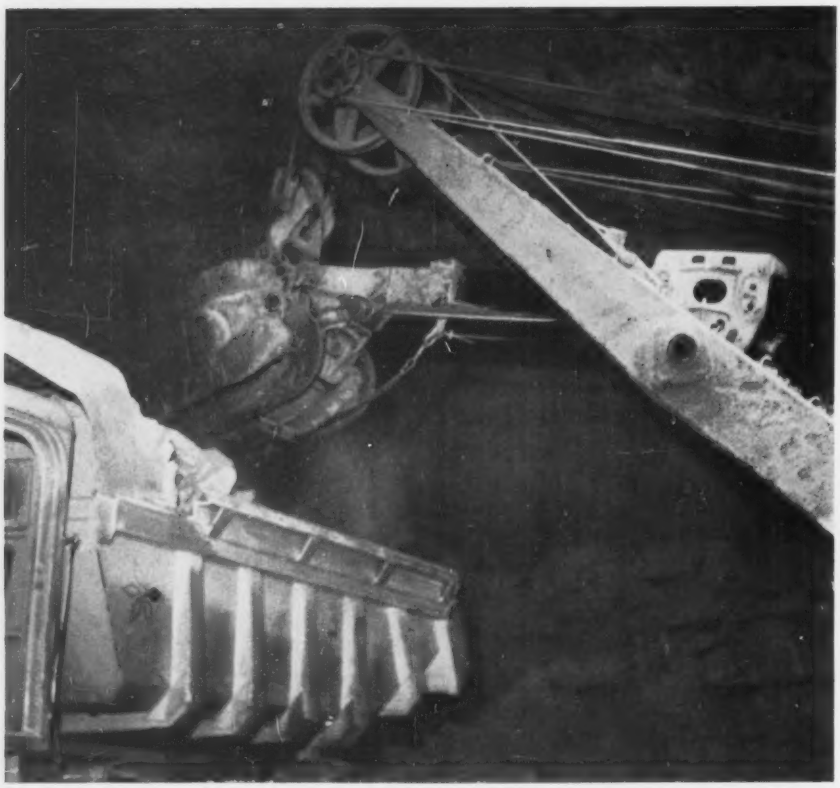
From the secondary crusher, where it is reduced to 1¼-in. maximum size, the salt again moves by conveyor belt to the secondary surge pile and then to measuring bins, where it is dumped automatically into one of the two counterbalanced 5-ton skips, which haul the product 1,000 ft. to the surface plus the equivalent of seven stories above the earth, where it is placed again in bins.

From these bins the salt is passed over vibrating screens that separate it according to size, ranging from ¾ in. to a substance as fine as flour and aptly called flour salt. The larger grades are bagged directly from the storage bins or dumped directly into freight cars at a maximum rate of 2 tons per minute. Table salt and other finer grades are packaged in an air-conditioned carton-packaging room.

Jefferson Island is located just off Louisiana Highway 14 which connects at New Iberia to U. S. Highway 90 and is also served by the Missouri Pacific Railroad. The company uses a canal from the mine to the Intracoastal Canal, giving unlimited access by barge.

With the excavation of a slope, the first step has been taken toward lowering the operation to the –1,400-ft. level. In about a year and a half, operations will begin at that level, where it is estimated there is enough salt to support normal operations for the next 50 years.

New Iberia, a colorful, predominantly French city of 29,000 population, and surrounding cities provide a ready labor supply. The actual mining operation employs about 38 men, ten of whom are in the maintenance division. Elridge LeBlanc and Paul Granger are production foremen. The mine engineer is Glenn Duvall.



HAULING: A Bucyrus-Erie 38-B shovel loads the blasted salt into a 17-ton Euclid dump truck for transportation to the primary crusher. In some sections of the mine, front-end loaders are used to load the trucks.

Mining Complex Ore At Idarado

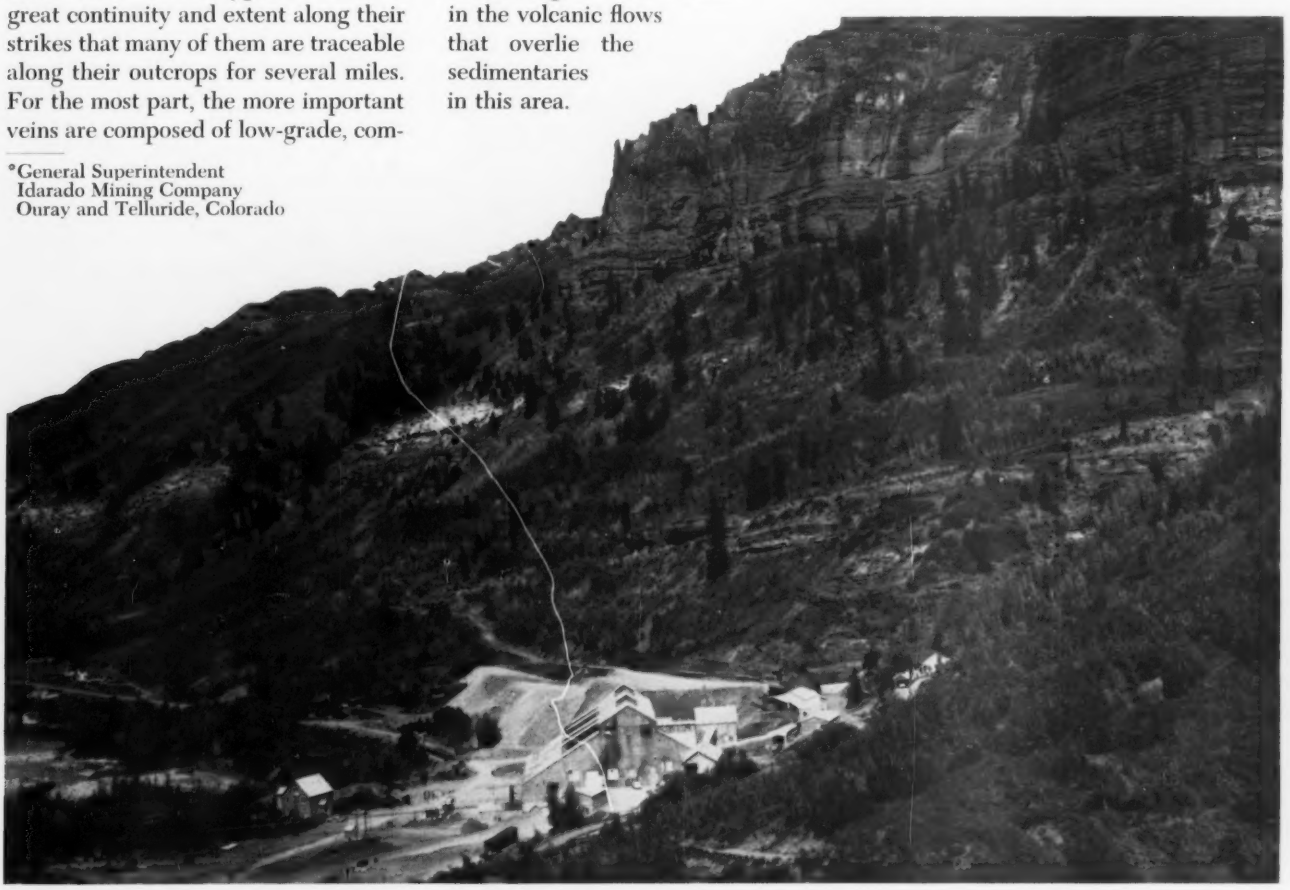
Progressive management, modern techniques, and a carefully planned development program constitute the creed of the highly successful Idarado Mining Company

A. C. HILANDER*

IDARADO MINING COMPANY is located high in the San Juan Mountains of Colorado's western slope, one of the most intensely mineralized districts in the world. This region is perhaps most famous for its fissure-type veins of such great continuity and extent along their strikes that many of them are traceable along their outcrops for several miles. For the most part, the more important veins are composed of low-grade, complex sulfide ores containing gold, silver, lead, copper, and zinc in varying proportions. Gangue minerals are most commonly quartz, fluorite, calcite, and rhodonite. The majority of the mining has so far been in the volcanic flows that overlie the sedimentaries in this area.

Early-day activity consisted mainly of the mining of the precious metals in the oxidized zone adjacent to the outcrops in the high mountain ridges and

*General Superintendent
Idarado Mining Company
Ouray and Telluride, Colorado



RUGGED TERRAIN: The Pandora Mill and surface plant are located high in the rugged San Juan Mountains near Telluride, Colorado. This area is one of the most intensely mineralized districts in the world.

DRILLING THE BLACK BEAR VEIN: Jacklegs with ⅞-in. hex. collared steel and single-use carbide bits have been found efficient for stope preparation. Idarado miners have an excellent productivity record, leading the state in production of silver, copper, and lead.

basins. As the gold and silver ores were mined down dip, their tenor decreased so that operators were forced to rely more and more on the recoverable base metals in order to sustain profitable operations. Today the mines have become primarily base metal mines with relatively minor amounts of gold and silver.

Progressive Expansion

Idarado Mining Company was formed in the late 1930's as a consolidation of a number of old mining properties, including the Black Bear, Treasury Tunnel, Barstow, and Imogene. By later acquisition, it became the owner of such famous mines as the Smuggler-Union, Liberty Bell, Tomboy, Montana, and Argentine. Thus, by the year 1953, Idarado had acquired a number of valuable and contiguous properties comprising a large acreage on the San Miguel-Uncompahgre watershed in San Miguel and Ouray Counties. This is the property as it stands today.

Current mining activity is being confined to mining on 7,200 ft. of strike length and 2,000 ft. of dip on the Argentine vein, a steep-dipping fissure-type vein trending northwest-southeast, and 5,000 ft. of strike length and 1,500 ft. of dip on the Black Bear, a flatter dipping vein splitting off the southeast extremity of the Argentine and trending more easterly and westerly. The elevation of this mining area ranges from 9,000 ft. to over 12,000 ft. above sea level. Many of the peaks in the area are from 13,000 to 14,000 ft. high and constitute some of the most rugged and scenic topography in the United States.

The mine workings are accessible through either of two active portals, the Mill Level portal at Pandora near Telluride at an elevation of 9,070 ft. or the Treasury Tunnel portal at Red Mountain near Ouray at 10,620 ft. The distance from portal to portal via the mine workings is 5½ miles, but it is 64 miles around the mountain by highway. As all the workings are interconnected by drifts and raises, access to any area in the mine may be had from either portal. As a consequence of this somewhat unique feature, the mine is able to draw from the labor market in several widely scattered towns, and roughly half the underground force enters at each portal.

Mineralization differs in the Argentine and Black Bear veins only in the quantities and proportions of gold and silver, and lead, copper, and zinc sulfides present; but mining of the Argentine vein is complicated by the presence of a barren premineral dike accompanying the vein. This dike may be present on either footwall or hanging wall and sometimes on both, and causes heavy ore dilution when broken. Mixing of the two vein ores is accomplished in the ore passes and is of great benefit in maintaining a reasonably constant head to the mill.

Mine Development

The mine is developed by tracked levels spaced 400 to 500 ft. apart on the vein. The levels are, in turn, connected by means of long raises also spaced 400 to 500 ft. apart and driven on the vein. The raises are also used for access to the stopes and as ore passes when their use for service is no longer necessary.

All broken ore for the Pandora Mill is brought down to the Mill Level haulage tunnel through a series of strategically placed ore passes, from which it is gathered by the haulage crews. The 1,800-ton-per-day mill operates three shifts a day five days per week and produces lead, copper, and zinc

flotation concentrates for shipment to the AS&R smelters at El Paso and Amarillo, Texas.

The steep pitch of the veins and their ideal 6 to 8-ft. average width lend themselves admirably to shrinkage stoping, and this method of mining has been used for many years in conjunction with sublevel slusher drifts for drawing the ore.

Stopes 200 to 250 ft. long are mined on either side of the raises. Service is either up the raise or down the raise, whichever is most convenient. When a stope has been mined upward a distance of 200 to 250 ft., a crown pillar is left, a sublevel slusher drift driven and prepared, and another stope mined above the lower completed stope.

Stope Preparation

Stope preparation at Idarado consists of driving slusher drifts, cutting footwall draw pockets on 25-ft. centers, and connecting the pockets together after hogging back to the vein. The slusher drifts are driven opposite each other from the service raises by two-man crews. Each man drills, blasts, and slushes out his own heading, completing this cycle once each shift. The heading is 6 by 7 ft. in size and is generally drilled 7 ft. deep for the round. Jacklegs with ⅞-in. hex. collared steel equipped with single-use carbide bits have been found most efficient for this work. Idarado has standarized on semigelatin explosives for all rock breaking, and Hercules® Regular Delay Electric Blasting Caps are used in all stope preparation and development work.

After the slusher drift has been driven out the normal stope length, pockets are cut with jacklegs in the footwall on 25-ft. centers. Then, using medium-weight, tappet-type stopers, the pockets are hogged back to the vein and connected. After the back of the stope has been squared up by the preparation crew, the stope is ready for the stoping crew.

The stoping crew, consisting of three men per shift—two of whom are machine men and one a slusherman and general utility man—assists with the loading of holes, the raising of cribbed ventilation manways, and the building of staging for drilling. A stoping crew will average about 22 holes drilled per man shift and upward of 50 tons broken per man shift.

Blasting

The ground in the Argentine is considerably harder than that of the Black Bear and requires more holes and, consequently, more explosives to break an equivalent tonnage of ore. Stope slices are generally drilled 6 ft. deep and 3 or 4 holes across the vein, depending on the width. The burden between rows of holes may vary from a maximum of 4 ft. in the Argentine to as much as 7 ft. in the Black Bear.

DIESEL-ELECTRIC LOCOMOTIVE: Designed by Idarado engineers and built in Idarado's shops, this 17-ton diesel-electric unit proved so successful that a similar, but lighter, unit is now under construction.

Here again, semigelatin explosives are used, but, because of the greater fragmentation effect, millisecond delay electric blasting caps are used almost exclusively in the stoping cycle. The exception to this practice is in the driving of fingers, hogging over of pillars, and occasionally the dogholing of footwall or hanging wall in search of vein walls or dikes.

In recent years, much attention has been paid to the upgrading of the ore, both as a matter of necessity and as good mining practice. Miners are directed to leave pillars in the stopes whenever there is danger of dilution from loose walls and to drop off low-grade areas, which are frequently encountered in some stoping areas of the mine. Careful and frequent sampling of the draw pockets in both active and completed stopes assists the engineers in calculating required tonnages to deliver a uniform feed to the mill.

Idarado has endeavored to maintain a policy of replacing, ton for ton, with new ore reserves the ore milled each year. This has been accomplished by means of a carefully planned development program of drifting, raising, and diamond drilling. Because of the sometimes erratic occurrence of the ore and the difficulty in achieving good vein intersections from a relatively small number of possible drill sites, diamond drilling is not considered to be very reliable in blocking out ore, but is used to determine favorable structure for later development by drifting and raising.

Drifting and Raising

In the drifting operation there are two men per crew per shift. They must install their own air-, vent-, and waterlines, lay their own rail to line and grade when necessary, and are expected to advance a round each shift. Eimco muckers are used for mucking out the round, and jacklegs are used exclusively for drilling. In the past year, the drilling of a large slot with super-size bits has been standard practice in drilling out the burn cut, and the resulting infallibility of this important part of the round has resulted in significant increases in footages advanced.

Drifts are on the order of 7 by 9 ft. in size, except on the upper levels of the mine, where they may be slightly smaller. Normally between 30 and 40 holes are required to break the ground, and regular delay electric blasting caps are used without exception. Holes are generally 7 to 9 ft. deep and 1⅝ in. in diameter. All drifts are ventilated with forced air and are equipped with battery locomotives for their means of service and transportation.

Raise crews consist of two miners and their service nipper. Crews are expected to raise their own timber, install pipe lines, ladders, and slide landings, and advance a 6-ft. round each shift. Because of the lesser trouble from ground conditions and the speed with which they can be driven, small

RED MOUNTAIN PLANT: The mine workings, because of a series of interconnected drifts and raises, can be reached by either of the two portals. Shown here are the Red Mountain surface facilities at the Treasury portal.

(6 by 10 ft.) two-compartment raises have become almost standard. Normally, the raises are driven on the vein, but when necessity demands it, they are driven on line and grade, in which case they may be considerably off the vein. The average raise will be from 400 to 500 ft. in height and is driven in one continuous lift. Some raises have been driven up to 900 ft. in height, in which case two lifts are required, with a station being cut for a second hoist installation at the 500-ft. level.

Drilling and blasting practices in the raises follow closely those used in the drifts, except, of course, light stopers are used instead of jacklegs. Forced ventilation is a necessity when driving the raise, and vent pipe is later stripped or converted to use as a compressed air line when the raise is completed.

All rock breakage is on an incentive system at Idarado. Payment is based on tons broken, as in the stopes, or upon feet of advance, as in the drifts and raises. The mine operates on a two-shift basis, which allows ample time for exhausting blasting fumes from the previous shift.

Idarado was one of the first metal mines to adopt diesel-driven equipment for main-line haulage. Today eight diesel locomotives, ranging in size from 8 to 17 tons, are in operation on the various haulage levels. Seven of these locomotives are of the torque converter transmission type. The largest and newest locomotive is a diesel-electric unit designed and built in the company's own shops, and has proved so successful that a similar, but lighter, unit is now under construction.

Management

Through an alert and progressive management and staff, Idarado tries to stay abreast of the newest developments in its segment of the industry. New equipment and products are constantly being tested to determine their worth in this type of operation; and when results and economics warrant it, a change is made.

The operation was the largest producer of silver, copper, and lead in the state for 1960, a distinction it has held for several years. A total of slightly under 300 employes is on the payroll. John S. Wise is the general manager; A. C. Hilander, general superintendent; John Kearney, mine superintendent; Kenneth Tatman, mill superintendent; William Griffith, mechanical superintendent; and John Keenan, chief engineer.

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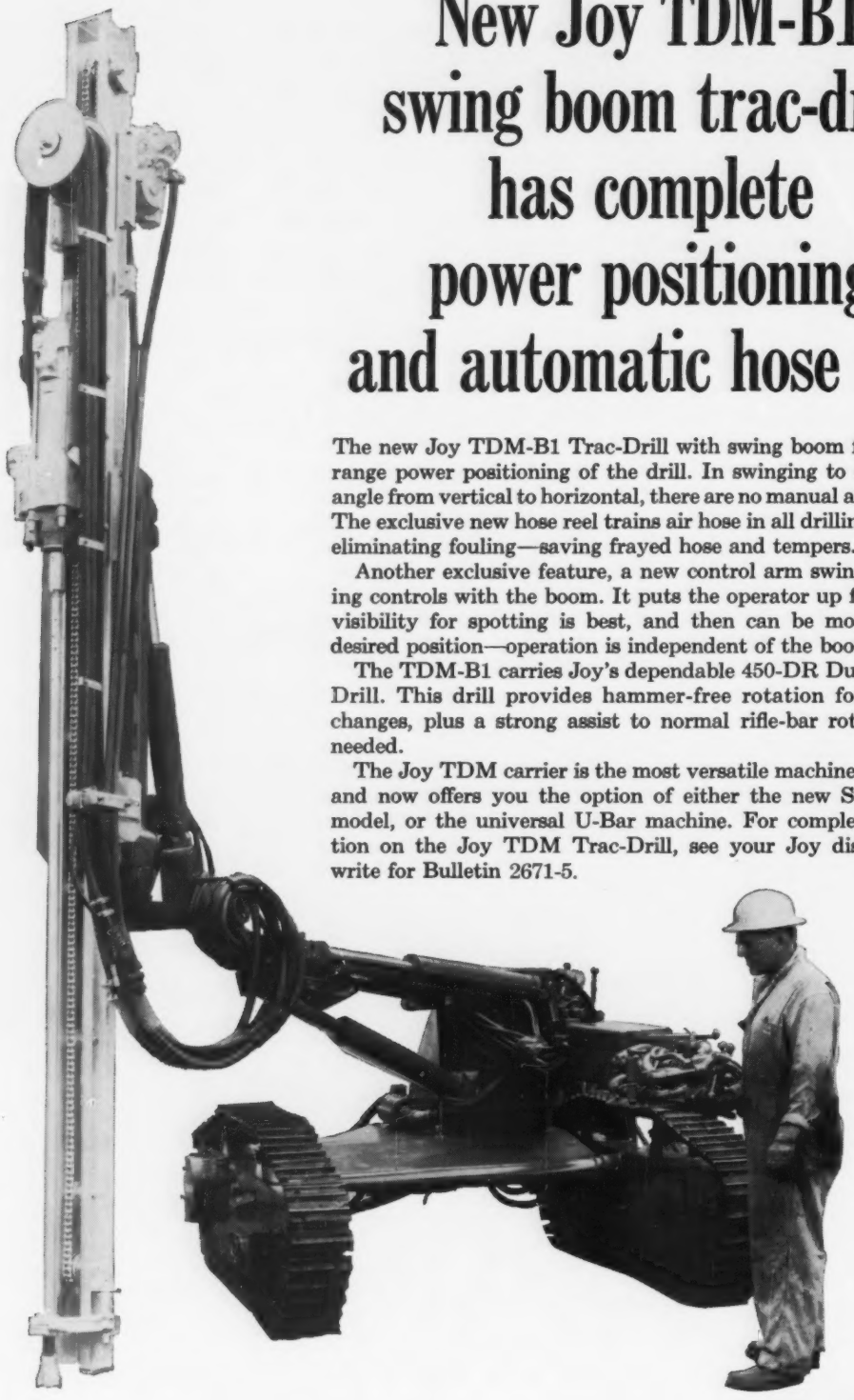

The new Joy TDM-B1 Trac-Drill with swing boom features full range power positioning of the drill. In swinging to any drilling angle from vertical to horizontal, there are no manual adjustments. The exclusive new hose reel trains air hose in all drilling positions, eliminating fouling—saving frayed hose and tempers.

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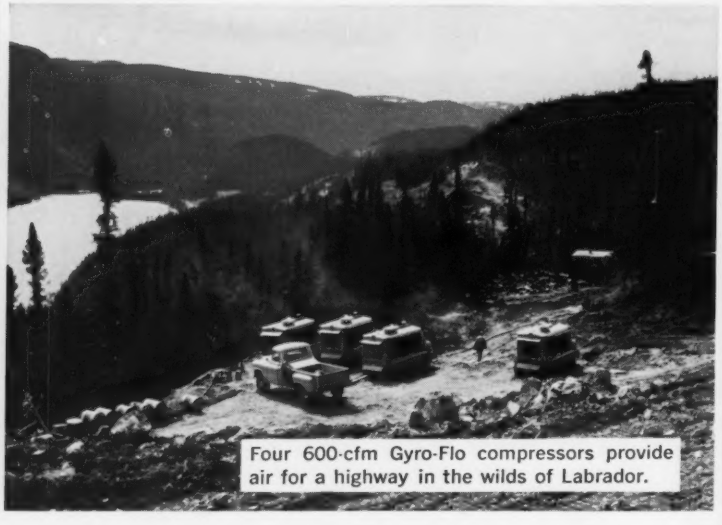

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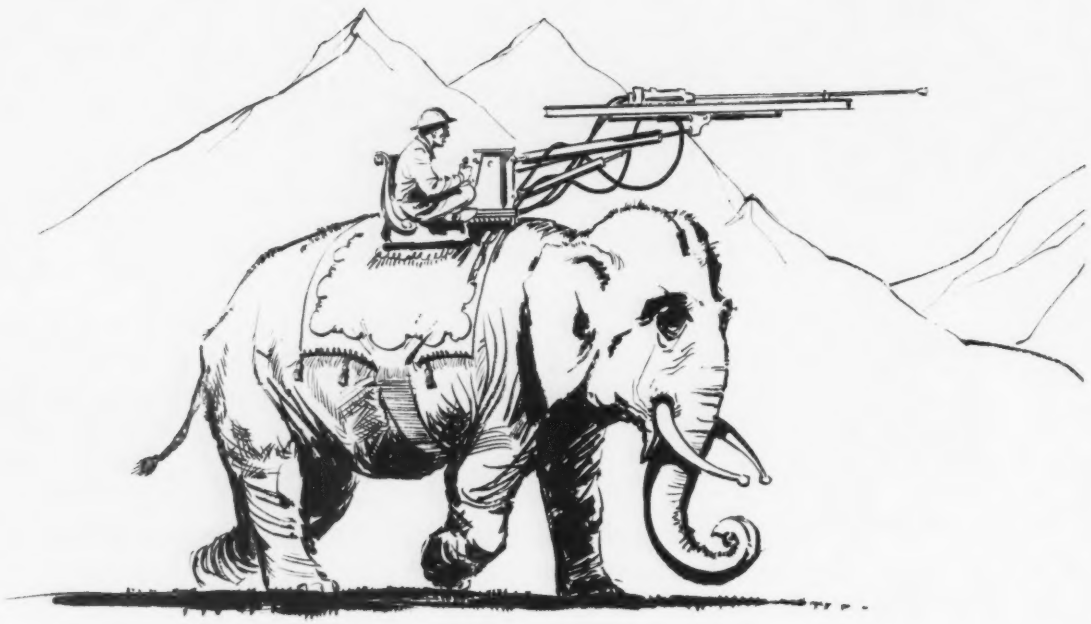

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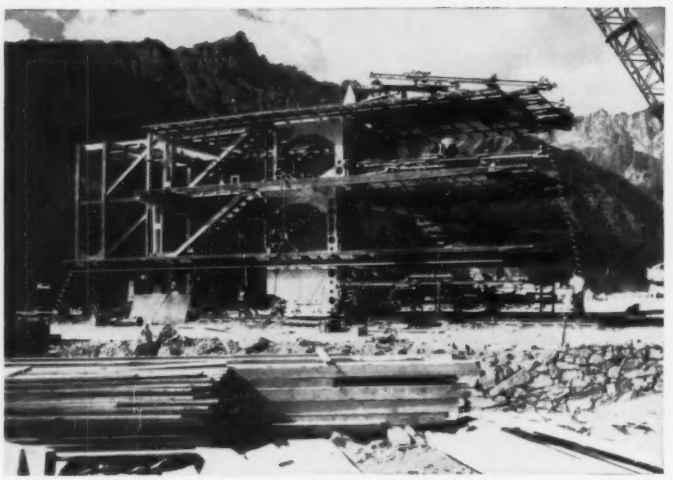

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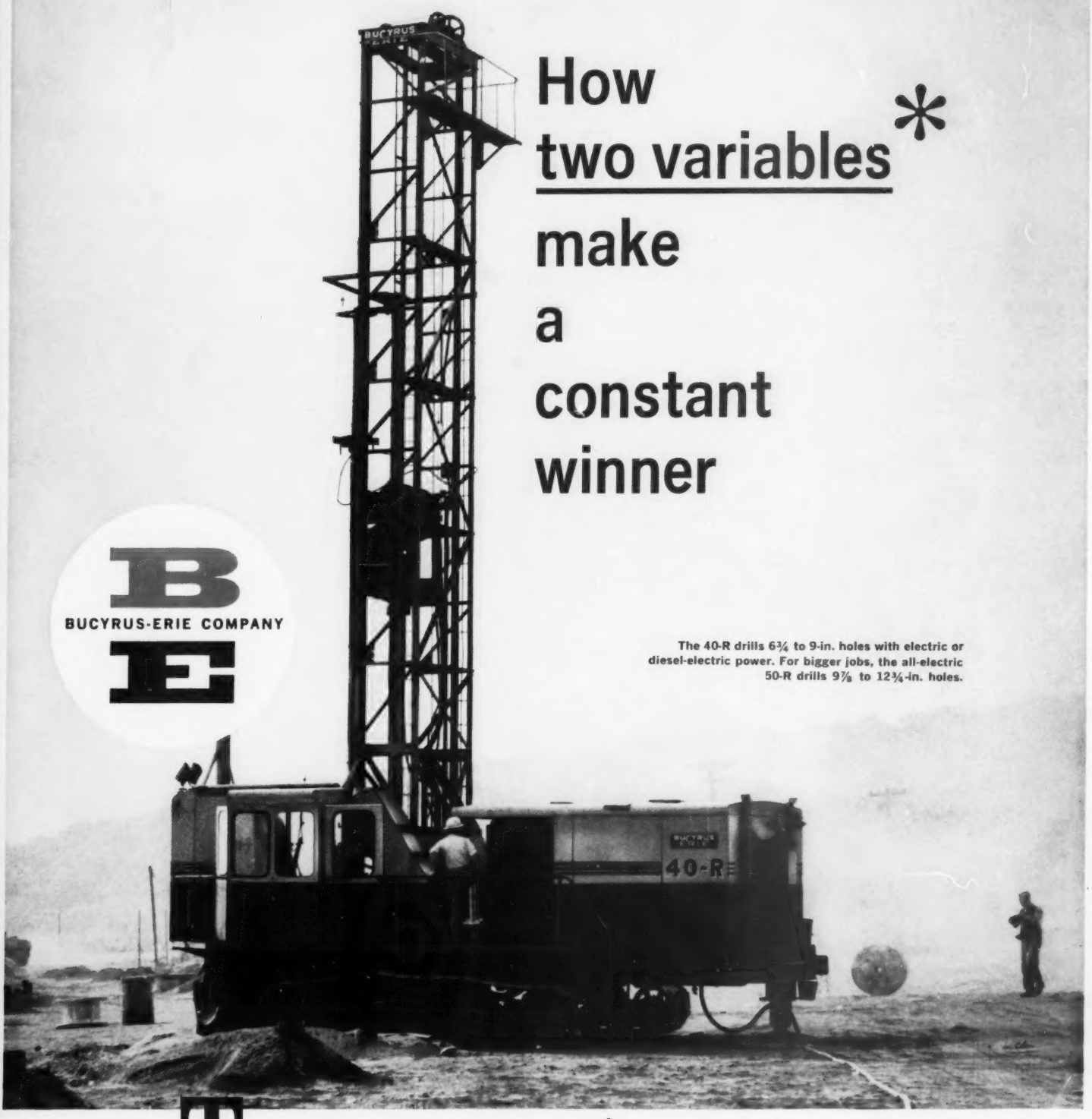

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